RNI: DELENG/2005/15153
Publication: 15th of every month
Posting: 19th/20th of every month at NDPSO

No: DL(E)-01/5079/11-13
Licensed to post without pre-payment U(E) 28/2011-13
Rs.100

ISSN 0973-2136

www.mycoordinates.org

Coordinates

Volume VIII, Issue 9, September 2012

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

Asia navigates ahead...

"IRNSS is expected to be realized by 2014-15"

"GAGAN enhances reliability and reduces delays to aircraft"

"BeiDou will enhance the comprehensive national strength of China"

"BeiDou system will focus on compatibility and interoperability with other GNSS"

WHY SETTLE FOR HALF A SOLUTION?

GNSS Requirements

220 Channels

L1/L2 GPS,
L1/L2 GLONASS

Centimeter RTK

Communication Requirements

3G Modem

WiFi/Bluetooth

Ethernet Interface

Web Browser GUI

Introducing the Trimble BD920-W3G.

The first precision RTK board with onboard 3G Modem, WiFi and Bluetooth® communications. Completely integrated in a compact 60 mm X 62 mm size.

GNSS plus communications, in one amazing package.

Find out more today at

www.trimble.com/gnss-inertial

See us at
ION GNSS 2012
Trimble Booth C

ION GNSS 2012

Trimble®

www.trimble.com

In this issue

Coordinates Volume 8, Issue 9, September 2012

Articles

Columns

This issue has been made possible by the support and good wishes of the following individuals and companies A S Ganeshan, Glendon G Newsome, James, Gregory Peake, L Farrell, Miyoun (Mimi) Dobbs, Pavel Davidson, Romayne Douglas, S K Shivakumar, V Somasundaram, Xingqun ZHAN and YANG Dongkai; and Ashtech, CHC, Datem, Effigis, Foif, Hemisphere GPS, HiTarget, Ifen, Javad, MicroSurvey, Pentax, Navcom, NovAtel, Racelogic, Riegl, South, Spectra, Trimble, Unistrong and many others.

Mailing Address
50 A Pocket A
SFS Mayur Vihar Phase III
Delhi 110 096, India.
Phones +91 11 22632607, 98102 33422, 98107 24567
Fax +91 11 22632607

Email
[information] talktous@mycoordinates.org
[editorial] bal@mycoordinates.org
[advertising] sam@mycoordinates.org
[subscriptions] iwant@mycoordinates.org

Web www.mycoordinates.org

Annual subscription (12 issues) [India] Rs.1,200 [Overseas] US$80

Printed and published by Sanjay Malaviya on behalf of Centre for Geoinformation Technologies at A221 Mangal Apartments, Vasundhara Enclave, Delhi 110096, India.

Editor Bal Krishna

Owner Centre for Geoinformation Technologies

Designed at Spring Design (springdesign@live.com)

Printer Thomson Press India Ltd., B 315, Okhla Phase I, New Delhi - 110020, India

This issue of Coordinates is of 60 pages, including cover.

BeiDou, GAGAN, IRNSS,...

Aspirations to actions

Brakes to breakthroughs

Confusions to confidence

Delays to deliverables

Endeavors to endurance

Fantasies to fundamentals

Guts to glory

Hindrances to hopes

Satellites to systems

Asia navigates ahead…

Bal Krishna, Editor
bal@mycoordinates.org

Collision avoidance by speed change

A collision avoidance strategy introduced more than ten years ago, being pursued in an investigation by Ohio University with NASA sponsorship, is supported by programming efforts that address dangerous scenarios. For aircraft that would collide if allowed to remain in their existing flight paths, conflict resolution can be provided by changing speed

James L Farrell
Vigil, Inc.,
Severna Park,
Maryland, USA

Speed change guidance strategy, combined with ModeS extended squitter data containing raw measurements from GPS/GNSS, has long been known to offer enormous advantages in safety, versatility, autonomy, and all aspects of performance for collision avoidance

Collision avoidance is one operation for which the many advantages of satellite navigation have not been developed. As noted in [1] the magnitude, multiplicity, – and importance – of potential benefits combine to make a compelling case for further consideration:

Integration : one system for both 3-D (in-air) and 2-D (runway incursions)
Autonomy: no ground station corrections required
Communication: interrogation / response replaced by ModeS squitter operation
Coordination : garble elimination through coordinated squitter scheduling
Tracking: all tracks maintained with GPS pseudoranges in data packets
Dynamics : tracks provide optimally estimated velocity as well as position
Timeliness: latency is counteracted through history of dynamics with position
Multitarget handling : every participant can track every other participant
Control: collision avoided by acceleration / deceleration rather than climb/dive

Recognition of these advantages over the existing pre-GPS **T**raffic Alert and **C**ollision **A**voidance **S**ystem (TCAS) has led NASA to support efforts toward exploiting these improvements. Details of the arrangement between NASA and Ohio University are described in [2] and [3]; work described herein is part of that overall investigation. Previous work is summarized only briefly here; present emphasis is on results.

As part of the NASA-sponsored effort, specific numerical results were generated for preventing conflicts impending with two aircraft (an "intruder" and an "evader") initially on a collision course. Over a wide range of conditions (i.e., intruder and evader speeds; angles between their velocity vectors), amounts of speed change required to produce a specified miss distance are readily computed. Results for sample conditions are plotted, along with the time to closest approach (which, due to the speed change, deviates from the time-to collision). The plots are followed by recommendations for adaptation to existing and future operation.

Existing methodology

An abbreviated description is given here for TCAS [4] which uses the history of range (instantaneous value of separation distance) and its rate of change to decide whether an advisory is needed. When the range is decreasing, the ratio of range to that closing rate, called time to go (TTG), is given the notation

$$\tau = (\text{range}) \,/\, (\text{closing rate}) \qquad (1)$$

That value is the time to collision for two aircraft on a collision course, characterized by zero rotation rate for the line-of-sight (LOS). Nonzero LOS rates produce, instead of a point of collision, a point of closest approach (PCA) and the corresponding closest approach time deviates from τ; TCAS applies "DMOD" adjustments in an effort to account for those departures.

Considerations just described are used to determine whether alerts or actions are needed. When evasive maneuvers are deemed necessary, they take place in a vertical plane; one aircraft climbs as the other dives.

TCAS limitations

A casual Internet search can uncover much concern about the abruptness – and a potential for unnecessary "dodges-just-in-case-the-azimuth direction…" – and the safety – of the climb / dive combination. Those and other capability restrictions are traceable to limited pre-GPS technology – highly dependent on transponders. With available information consisting of highly accurate range and less accurate altitude, imprecise nature of the latter is not the main limitation; note the absence of timely horizontal cross-range (azimuth) measurements. Although cross-range estimates can be deduced from histories of range and ownship dynamics, those estimates evolve only indirectly, critically dependent upon LOS rotation; they are neither as accurate nor as timely as needed. Indeed, LOS rotation sufficient to provide azimuth observability occurs only at close ranges – precisely the condition necessary to avoid.

Absence of direct azimuth measurement data translates immediately to absence of most beneficial features listed in the **Introduction**. Rather than a criticism of TCAS design, then, a comparison of capability is presented here as an intrinsic result of a fundamental trait: direct 3-D observability. In addition, the proposed methodology will offer feasibility of operating with an intruding aircraft being

- oblivious to imminent danger, thus nonmaneuvering
- nonparticipating altogether; by operational extensions not shown here but covered on p. 203 of [5].

Modernized approach

With extended squitter data containing direct GPS measurements [2,3,6], all major error sources either cancel or can be readily rejected by straightforward data editing [7]. A host of advantages materialize instantly [8]. Track files are obtained and maintained from that comparison of time- stamped raw GNSS measurements. Errors in perceived position – including errors in projected future distances near PCA – can then be made smaller than requisite miss distances. The projected future miss distances can be enlarged through speed control decisions based on the accurate 3-D track files.

Speed can be increased or decreased, whichever is deemed most suitable. Once a speed change is prescribed there is no reason to delay action; they are treated here as instantaneous *but* not excessive since

- abrupt speed increase is impractical if unduly large
- large reductions in speed risk stall.

Applicable conditions

Before addressing the most general class of conditions, a meaningful set of guidelines governing two aircraft must be clearly established. Scenarios to be considered here thus consist of two moving participants, termed *intruder* and *evader*. There can be, in addition, stationary observers (e.g., a tower) monitoring – and possibly communicating with – either or both of them. For maximum safety the selected methodology will enable success when the intruder is oblivious to any danger; thus corrective action is assigned only to the evader.

Not every dangerous scenario is amenable to solution via speed change. Deceleration, for example, cannot avert a head-on collision. By extension of that reasoning, faster closing rates tend to demand wider variations in speed. Using that rationale, then, a first step is to impose some limits on applicable geometries. Criteria involving range and closing rate, already described, will likewise be used here.

Depending on the evader and intruder velocity directions, the closing rate may be greater or less than evader speed. With higher closing rates being the most challenging (again by extension of the limiting head-on case), it is not surprising that they offer the narrower span. To preclude excessive demands for speed change, values exceeding 130^0 or less than 30^0 are considered candidates for resolution by turns, beyond scope here. Within the 30^0 - 130^0 spread it was found expedient to increase speed for heading differences above 90^0 and reduce it below.

Illustrative examples

For the scenario in Figure 1 the origin is set at the point where collision would occur in two minutes if no corrective action ever happened. With a 450-knot (*231.65* m/sec) initial speed the evader then begins at a location $231.65 \times 120 = 27798$ meters from the origin. Depicting that location here along the North/South line does not affect the computed results – a simple subtraction (intruder heading) - (evader heading) will rotate the cardinal directions relative to the image in a more general case. The *350*-knot intruder starts from a location backed away from the origin, along a 120^0 line (heading is synonymous with ground track in this simplified analysis), by $180.17 \times 120 = 21620$ meters. By orienting one reference direction (here the y-axis) of the *ENU* coordinate frame along the evader's path, only that *y*-component of speed change *v* need be computed. Given the separation vector **R** at any time (e.g., for the initialization just shown), the requisite speed change is formed by subtracting $[0\ v]^T$ from the initial (intruder - evader) relative velocity, forming the unit vector **n** perpendicular to that direction, and setting the component of **R** along **n** equal to a chosen a scalar miss distance D (*1* km). Imposing that condition produces a quadratic equation, offering an increase and a decrease in speed, both of which conform precisely to D. In either case the time t_{CA} to closest approach (computed by nulling the component of **R** *parallel* to the post-acceleration / deceleration relative velocity vector) deviates from the two-minute time-to-collision.

For the next example a case was run with similar parameters (*2* min, *1* km, *450* kt, *350* kt) but with a 45^0 heading difference. Once again the minimal separation distance (*1* km) occurs when **R** becomes perpendicular to the relative velocity, computed by simple time extrapolation as described at the end of the preceding paragraph. In this case that happens at

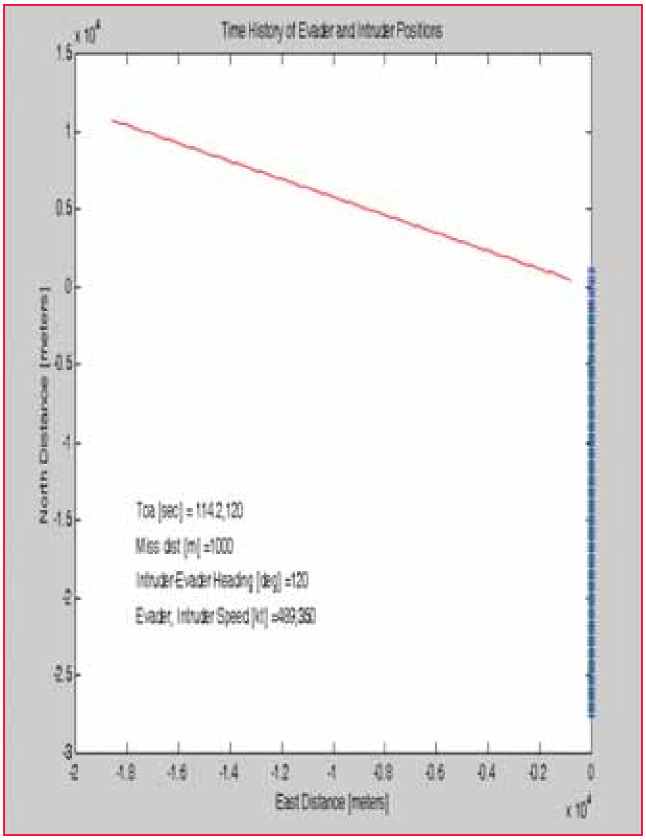


Figure 1: Speed Increase Scenario

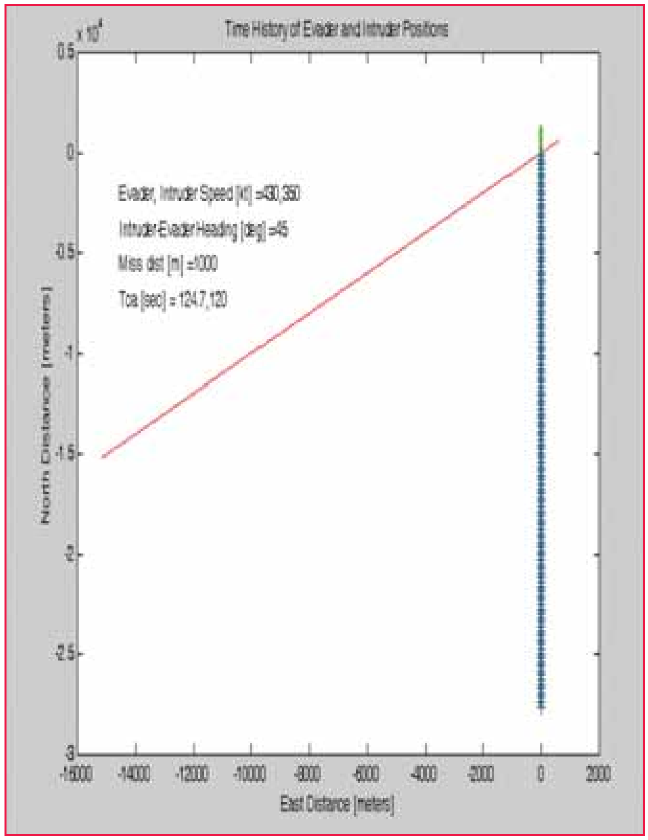


Figure 2: Speed Reduction Scenario

a later time since (recall the end of the preceding section), speed reduction was chosen; thus t_{CA} exceeds the two-minute time-to collision in this case.

While the first scenario evolves in a way easily visualized from Fig. 1 (separation distance decreases until reaching final positions shown), Fig. 2 is slightly more complex. The evader's actual path (thick line, Northbound) doesn't reach the intruder's path until the intruder has passed. An extension of the evader's path (shown as a lighter, thinner line) shows how it would have progressed without the speed reduction – except that a collision would have occurred where the two paths intersect. A simple animation in the form of a Matlab "movie" appears in [9].

Performance with General conditions

Sets of runs were made for generation of plots showing results obtained with the following parameter values:

- intruder heading at values from 30^0 to 130^0
- intruder speed at *200*, *300*, and *400* knots
- *2* minutes to collision for evader speed at initial value
- initial evader speed at *500* knots
- evader speed change chosen for 1 km miss distance

In all cases the evader was headed due North and, if the evader speed had remained at its initial value, a collision would have occurred at the point designated as the origin. With intruder heading as the abscissa, plots were generated for time to closest approach t_{CA} and for evader speed change (increasing for intruder headings above 90^0 and decreasing below 90^0, as previously noted). Miss distances obtained were also plotted (to ensure conformance to chosen input values) but, since they were always in precise agreement, there is no need to show those plots here.

The three different intruder speeds are not labeled on the figures but, for these plots, the "inside" curves (those with the smallest speed change and the smallest average t_{CA} departure from *120*-sec) are for the *200*-kt intruders; the "outside" curves (those with the largest speed change and the largest average t_{CA} departure from *120*-sec) are for the *400*-kt intruders; the *300*-kt intruders curves lie between.

From running many cases it was found, propitiously but not surprisingly, that lower evader speeds demand smaller amounts of speed change. The same trait holds true for the amount of departure between t_{CA} and the time-to-collision. It is worth noting that, when the guidance algorithm produces acceptable values for speed change and t_{CA}, they can be recomputed with miss distance increased to account for uncertainties introduced by tracking errors.

Although not mentioned thus far, and not noted on the plots, all evader flight path modifications indicated here include another feature: a gradual climb, starting at the same time as the speed change. In order to avoid a wake problem (which would otherwise

PENTAX GNSS G3100-R1

PRECISION SATELLITE SURVEYING WITH WIRELESS COMMUNICATIONS

Positioning systems

- **Single Rugged Lightweight** Housing
- **State of the Art** 136-channel AsteRx2 **Receiver** with GPS/GIONASS
- **Integrated Satellite Antenna** for Optimized Satellite Tracking
- **Base** or **Rover** Configuration
- **Multiple Communication Choices**
- **Hot Swap Batteries** with Fuel Gauges
- **Easy Removable SD Card** for Data Logging
- **Bluetooth Controller**
- **Rugged Field Controller** with Field Genius for Efficient Field Survey

TI Asahi Co., Ltd.
International Sales Department
Tel.: +81-48-793-0118
Fax. +81-48-793-0128
e-mail: international@tiasahi.com

PENTAX FIELDGenius

Compatible with EZSurv™ GNSS post-processing Software

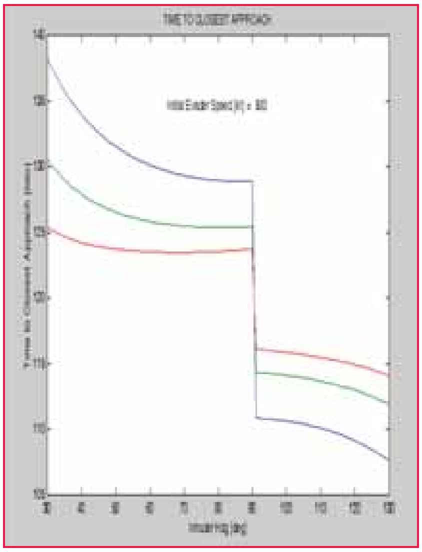


Figure 3: t_{CA} for 500 kt Initial Evader Speed

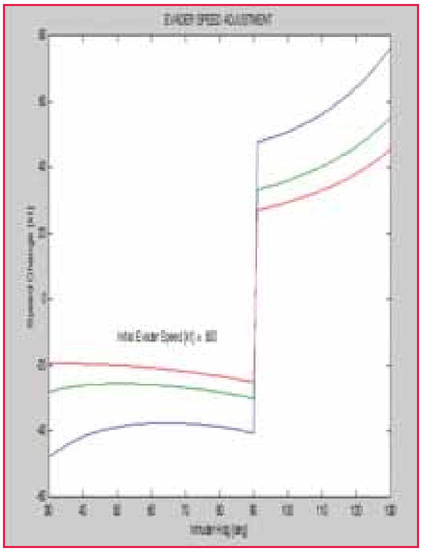


Figure 4: Evader Speed Change from 500 kt Initially

arise from flying through the same air just vacated by the intruder), the evader would be instructed to climb to the same final altitude that TCAS would have prescribed. In marked contrast to TCAS, however, this climb would be gradual. The proposed method, then, provides only half of TCAS's vertical separation (the intruder can be nonparticipating), but a substantially larger horizontal separation can be commanded.

Recommended future work

It is acknowledged that the results shown here only begin to describe collision avoidance strategies. Refinements can be added (e.g., accounting for wind, finite time elapsed during speed changes, etc.) and, of greater importance, extensions will be needed for three-dimensional scenarios, increased numbers of participants, and turn scenarios for heading differences below 30^0 or beyond 130^0. At least in the near term two further modifications are likely to become necessary:

- acceptance of guidance from elsewhere (e.g., tower)
- operation in concert with, rather than substitution for, TCAS.

The last item was described in [3] as a preemptive approach. Rather than providing the whole guidance for collision avoidance, speed changes could be introduced further in advance of PCA, for purposes of preventing TCAS resolution advisories from being generated. Finally, all applicable algorithms and programs will have to be submitted for documentation in a standardized form; this clearly fits within the realm of capabilities too important to be limited by any proprietary claims.

Throughout this development a capability not yet fully realized in operation has been taken for granted. Usage of air-to-air track methods, known from decades-old radar applications [10], must be adapted with GNSS double differences replacing radar observables. Since tracking algorithms in a stable (INS-based) reference frame (summarized in [11] and detailed in Chapter 9 of [5]) have long been established, and since GNSS measurements far surpass radar in accuracy, success of that substitution awaits only a commitment to support a brief extension followed by flight validation.

Means to bring this capability into operation, then, are entirely within reach. The need to follow through is urgent – and the urgency can only grow with increasing occurrence of a recently adopted practice: usage of unmanned aircraft.

Conclusions

Speed change guidance strategy, combined with ModeS extended squitter data containing raw measurements from GPS/GNSS, has long been known to offer enormous advantages in safety, versatility, autonomy, and all aspects of performance for collision avoidance. Quantitative results are easily obtainable for a wide range of applicable scenarios.

References

[1] Collision Avoidance By Deceleration http://tinyurl.com/JLF-link13

[2] Uijt de Haag, M. and Farrell, James L., "Collision Avoidance for Future Operation," IEEE-ICNS Conference, Arlington VA, May 2009.

[3] Uijt de Haag, M., Vana, S., and Farrell, James L., "Simulation Model to Evaluate Collision Avoidance Methods using Raw Measurements in the Automatic Dependent Surveillance – Broadcast," ION-GNSS 2011, Portland OR

[4] Introduction to TCAS II, US DOT-FAA Booklet, March 1990.

[5] Farrell, James L., GNSS Aided Navigation and Tracking, American Literary Press, 2007 – http://tinyurl.com/JLF-link4

[6] Farrell, James L., McConkey, E.D., and Stephens, C.G., "Send Measurements, Not Coordinates," IONJ v46 n3 1999, pp 203-215.

[7] Single-measurementRAIM http://tinyurl.com/JLF-link17

[8] http://jameslfarrell.com/gps-gnss/surveillance

[9] http://www.youtube.com/watch?v=auoNAd-JP4A

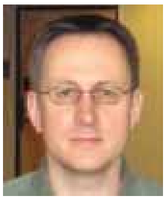
[10] Farrell, James L. And Quesinberry, E.C., "Track Mechanization Alternatives," NAECON Symposium, Dayton Ohio, 1981.

[11] http://jameslfarrell.com/tracking/cartesianvsspherical

The author is indebted to Ohio University for support of this work.

A novel approach to autonomous pedestrian navigation

This approach is an alternative to foot-mounted pedestrian navigation systems. A kinetic model of human gait is used as a virtual velocity sensor to curb the divergence of INS computed horizontal velocity and tilt errors



Pavel Davidson
Researcher
Department of Computer Systems
Tampere University of Technology, Finland

Dynamics of human gait is a unique source of external velocity aiding for pedestrian navigation systems that has largely been overlooked by the engineers

High-performance autonomous pedestrian dead-reckoning (PDR) systems usually include 6 degrees-of-freedom (DOF) inertial measurements unit (IMU) to calculate position of the user. These systems don't rely on GPS signals and preinstalled infrastructure such as RF beacons, Wi-Fi routers, ultrasonic transmitters etc. Standard inertial navigation system (INS) calculates position by temporal integration of IMU data that comes from three accelerometers and three gyroscopes. Estimated position is calculated at regular time intervals. The unaided INS's position, velocity and attitude errors grow with time and can be quite significant especially when IMU consists of low-cost MEMS sensors. Therefore traditional unaided INS mechanization is impractical for pedestrian navigation.

One way to curb the divergence of errors in INS is to use external velocity and position aiding. In indoor scenarios without preinstalled infrastructure the options for external velocity and position aiding are very limited: building floor plans can be used for position update, Doppler radars for velocity update. But even these options are not always available.

An alternative navigation method takes advantage of biomechanics of walking. Recognizing that people move one step at a time, the pedestrian mechanization restricts error growth by propagating position estimates in a stride-wise fashion, rather than on a fixed time interval. Inertial sensors in a pedestrian dead reckoning (PDR) system are used to detect the occurrence of steps, and provide a means of estimating the distance and direction in which the step was taken. In this way position error is proportional to the number of steps or traveled distance. Many current PDR systems use foot mounted IMU which allows for zero-velocity update at every stride.

In this paper we propose a novel approach for velocity update based on knowledge of human walking process. It can be applied to PDR systems that include body-mounted IMU at waist or torso, which in some applications can be advantageous compare to foot-mounted sensors. The knowledge of human gait dynamics gives us an alternative way to calculate traveled distance and velocity averaged during the step, which can be considered as a virtual measurement. The different characteristics of errors in INS output and in this virtual measurement make it possible to apply complementary filter methodology and significantly improve INS performance by keeping the horizontal velocity and tilt errors small. The processing of corrected IMU output results in accurate estimation of stride length and direction. This paper presents the real-world results from pedestrian indoor walking tests.

Dynamics of human gait

Dynamics of human gait is a unique source of external velocity aiding for pedestrian navigation systems that has largely been overlooked by the engineers. Analysis of the human gait shows that the basic pattern of human motion during a walk is cyclical, repeatable and remarkably consistent between individuals [1]. At normal constant walking speed, the vertical and horizontal components of the body's centre of gravity velocity oscillate smoothly with the frequency equal to the step frequency.

The amplitude of vertical acceleration and vertical displacement are proportional to the step length. As a result, the stride events as well as stride length can be estimated using models of gait dynamics and measured motion parameters. When a foot hits the ground significant vertical acceleration is generated by the impact. Therefore the algorithms for stride occurrence detection can be based on the analysis of the acceleration pattern during walking. For example, the body-mounted accelerometers can detect maximum or minimum of the vertical acceleration, which corresponds to the step occurrences. If the vertical acceleration exceeds the pre-defined threshold then the step occurrence is detected. Since the pattern of acceleration depends on type of movement (walking, running, going up or down stairs, etc.) and type of ground over which the person walks (hard, soft, slippery surface) the determination of threshold for reliable step detection is not so easy [2][3].

Another way to process accelerometer data for step detection is to use zero-crossing of the acceleration magnitude signal. The zero-crossing method requires a tri-axial accelerometer to measure pedestrian movement. The magnitude of the acceleration vector can be computed by subtracting the local gravity from the measured magnitude of the acceleration vector. Footfall recognition is based on determination of the zero crossing of the acceleration magnitude signal. Since the norm of the acceleration vector is used for the orientation of the sensor unit, it has no effect on the measurement. Step detection is triggered when zero crossings fit in the recognition window [5].

The step length depends on several factors such as walking velocity, step frequency and height of walker etc. The algorithms for step length estimation generally fall into two groups: (1) algorithms based on biomechanical models and (2) algorithms based on empirical relationships. The example of the step length estimator based on empirical relation between the vertical acceleration and the step length is given by

$$\Delta L_2 = K\sqrt[4]{a_{\max} - a_{\min}} \qquad (1)$$

where a_{max}, a_{min} are the maximum and minimum values of the vertical acceleration during the step. These algorithms show good performance during normal walking on flat terrain. The step length estimation error is 2-5% of distance [4]. The performance of this algorithm degrades rapidly when a person is walking, for example, on non-flat terrain or climbing on stairs.

Average speed during the step can be calculated as the ratio between the step length and step duration. This ground speed can be also resolved into the north and the east velocity components using INS computed heading averaged over the same step. Thus the estimation of pedestrian velocity during the step is obtained. Since the velocity error of this kinetic model based estimator is a result of several independent error sources such as model error, measurement error, inaccuracy in step occurrence events it has a random distribution and can be approximated as Gaussian noise.

Fusion of IMU data and pedestrian dynamics

In our pedestrian navigation system, the body mounted IMU contains three gyros and three accelerometers that measure the projections of absolute angular rate and specific force on their sensitivity axes. The navigation computations are performed in the local-level coordinate frame. The transformation matrix from the sensor frame to the local-level frame is calculated using output from gyroscopes. The mechanization equations are implemented as local-level terrestrial navigator without vertical channel.

Position, velocity and attitude errors in a stand-alone INS grow with time. For short period of autonomous operation (1-1.5 hours) the propagation of horizontal velocity errors and tilts can be approximated by the Schuler oscillations. When the INS is assumed to be nominally level with altitude compensation and constant low speed, the single north channel error model is described by the following equations [8][9]:

$$\begin{aligned} \delta\dot{V}_E &= -g\phi_N + B_E \qquad (2) \\ \dot{\phi}_N &= \frac{\delta V_E}{R} + \varepsilon_N \\ \delta\dot{V}_N &= g\phi_E + B_N \\ \dot{\phi}_E &= -\frac{\delta V_N}{R} + \varepsilon_E \end{aligned}$$

where $\delta V_E, \delta V_N$ are the north and east components of velocity error, ϕ_E, ϕ_N are the horizontal tilt errors, $B_E, B_N, \varepsilon_E, \varepsilon_N$ are the projections of accelerometer biases and gyro drifts on the local-level frame. The equations for the east channel are similar to eqs. 2. Note that under above assumptions the north, east and vertical channels are not coupled and can be processed separately. The block diagram representation of INS's north channel is shown in fig. 1 by solid lines [9]

A well known in control theory approach for oscillation damping is based on feedback loop to control the dynamic behavior of the system. A partially measured output is fed back to the controller where the difference between the reference and the output is amplified to change the input in desired way and obtain improved system performance. The damping of INS errors can be implemented using the external velocity information. The control inputs are shown in fig. 1 by the dashed lines. The gains □□ and □□ can be pre-computed or calculated online.

In the case of pedestrian navigation, the kinetic model of gait is considered as a virtual sensor that can be used to estimate the step events and step size for a person while walking. As a result, the estimations of step size and step duration can be used to calculate average velocity over each step. The error of calculated average velocity consists of the errors in step length model, inaccuracy in determining step duration, accelerometer measurement errors. The error components are not correlated with each other thus making the error in velocity random with little correlation in time. Since the error of this estimated average velocity is also not correlated with INS velocity error it can be used as an external velocity measurement for INS.

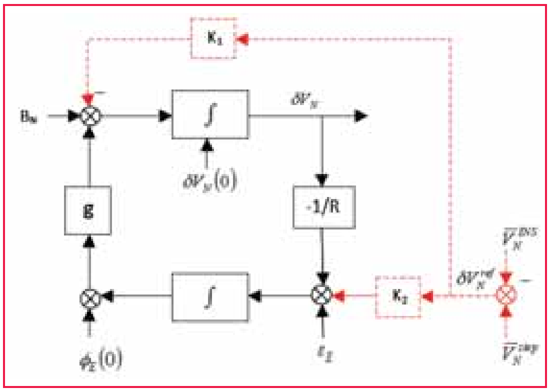


Figure 1: Diagram of the INS's north channel error damping

Even when a person is walking with almost constant speed, the velocity profile within each step reveals variations of about 0.3 m/sec around the average walking speed. Since the indicated INS velocity follows the same profile, the comparison of momentarily INS velocity with average velocity in not appropriate. Instead, the indicated INS velocity averaged over one step can be compared with average velocity from an external measurement. As a result of this comparison, an estimation of the INS velocity error can be obtained. Since the INS velocity error changes slowly it can be assumed constant during one step. In this case, averaged over one step, INS indicated velocity is calculated as the true average velocity plus the velocity error. The measurement of the INS velocity error can be obtained by taking the difference between INS velocity, averaged over one step and the kinetic model computed velocity:

$$z=\begin{bmatrix}\bar{V}_N^{INS}-\bar{V}_N^{step}\\ \bar{V}_E^{INS}-\bar{V}_E^{step}\end{bmatrix}=\begin{matrix}\delta V_N^{INS}+w_N\\ \delta V_E^{INS}+w_E\end{matrix} \qquad (3)$$

Here w_N, w_E are the velocity errors of the kinetic model based velocity estimator. While calculating the INS velocity error using (3), it was also assumed that the velocity estimated based on the kinetic model has a random error which is assumed to be distributed as a random Gaussian noise. This virtual measurement of INS velocity error can be performed at every step.

The mathematical system model for horizontal velocities and tilts is formulated in terms of error state space. Only the north channel equations are described since the data processing for the east channel is similar. Since in pedestrian navigation systems the accelerometer bias has smaller effect than the other error sources there will be three variables of primary interest for each channel: error in INS indicated velocity, tilt error, and gyro drift rate. In terms of these variables, the state differential equations for the north channels become:

$$\begin{bmatrix}\delta\dot{V}_N\\ \dot{\phi}_E\\ \dot{\varepsilon}_E\end{bmatrix}=\begin{bmatrix}0 & g & 0\\ -1/R & 0 & 1\\ 0 & 0 & 0\end{bmatrix}\begin{bmatrix}\delta V_N\\ \phi_E\\ \varepsilon_E\end{bmatrix}+\begin{bmatrix}n_a\\ 0\\ n_g\end{bmatrix} \qquad (4)$$

where n_a, n_g, is the noise. The measurement to be used as the input to the Kalman filter is the difference between average velocities given by eqs. 3 [10].

Figure 2: The assembly of 6 DOF IMU, batteries and readout electronics.

Experimental results

The proposed method for INS velocity aiding was tested with actual data from the indoor walking tests. The 170 meter test route inside the typical office building is shown in fig. 3. The true pedestrian path is shown by green solid line. The test scenario included different types of movement: walking with variable step length and frequency, going up or down stairs, standing, making sharp turns and opening the doors. The total time of the test was about 5 minutes. The pedestrian dead-reckoning system included 6 DOF IMU, which is composed of three VTI Technologies SCC1300-D02 combined gyroscope and accelerometer with digital SPI interfaces [11]. This is a self-contained device for inertial data collection. In addition to three gyros and accelerometers, it includes also the batteries, memory card and all the necessary electronics for data collection. The complete unit is shown in fig. 2.

The INS computed path is shown in fig. 3 by the magenta asterisks. Our method can reduce only the distance error in PDR systems. Along-track (distance) error during this test does not exceed 2% of travelled distance. The results can be improved when horizontal gyros' drifts are compensated. But the largest error is caused by heading error. Heading cannot be corrected with this algorithm and other methods, for example, map-matching can be used to reduce the heading error.

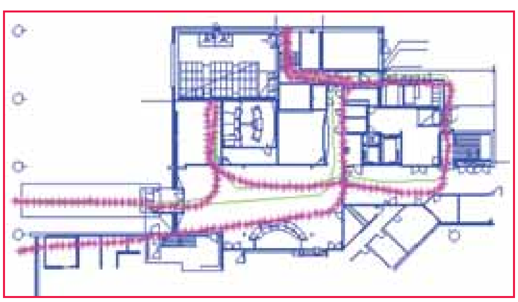


Figure 3. The walking path inside the building: The true path is shown by the green solid line. The INS computed path is shown by the magenta asterisks.

Conclusions

We proposed a novel approach for INS external velocity aiding in pedestrian navigation systems. Our approach can be applied to body-mounted INS which in some applications can be advantageous compare to foot-mounted sensors mainly because the body mounted IMU is isolated from shocks and high dynamics. For the same MEMS gyros the measurement error can be significantly higher if the gyros are exposed to shocks. Therefore the PDR systems with body mounted IMU have better performance in heading estimation. In addition to this, the body mounted IMU is preferable for the motion classification.

The method uses kinetic model of human gait which gives us an alternative way to calculate traveled distance and velocity averaged during the step which can be considered as a virtual velocity measurement. The different characteristics of errors in INS output and in this virtual measurement make it possible to apply complementary filter methodology and significantly improve INS performance by keeping the horizontal velocity and tilt errors small. The distance error is about 2% of traveled distance. Our approach does not have restrictions on pedestrian movement. However reliable velocity update is possible only during normal walking or standing.

Acknowledgement

The author would like to acknowledge the contributions of Olli Pekkalin, Arto Perttula and Jussi Collin in collecting field data.

References

[1] Stirling R., "Development of a Pedestrian Navigation System Using Shoe Mounted Sensors," MSc thesis, University of Alberta, 2004.

[2] Ladetto Q., "On foot navigation: continuous step calibration using both complementary recursive prediction and adaptive Kalman filtering," in proceedings of ION GPS conference, 2000.

[3] Ladetto, Q., Merminod B., "Digital Magnetic Compass and Gyroscope Integration for Pedestrian Navigation" 9th International Conference on Integrated Navigation Systems, St-Petersburg, May 27-29, 2002

[4] Jahn J., Batzer U., Seitz J., Patino-Studencka L. and Boronat J., "Comparison and Evaluation of Acceleration Based Step Length Estimators for Handheld Devices," International Conference on Indoor Positioning and Indoor Navigation, Zürich, Switzerland, 15-17 September 2010.

[5] Matthews C., Ketema Y., Gebre-Egziabher D., Schwartz M., "In-Situ Step Size Estimation Using a Kinetic Model of Human Gait," in proceedings of ION GNSS, Portland, OR, September 21-24, 2010.

[6] Ashkenazy Y., Hausdorf J., Ivanov P., Stanley E., "A stochastic model of human gait dynamics", Physica A: Statistical Mechanics and its applications, vol. 316, issue 1-4 December 2002.

[7] Yan Cui, Ariyur, K.B., "Bounding inertial drift with human gait dynamics for personal navigation", IEEE International Systems conference, 2011.

[8] Farrell J., and Barth M. 1999. "The Global Positioning System and Inertial Navigation," McGraw-Hill, 1999

[9] Salychev O., "Applied Inertial Navigation: Problems and Solutions," BMSTU Press. Moscow. 2004

[10] Davidson P., and Takala J., "Algorithm for Pedestrian Navigation Combining IMU Measurements and Gait Models," 19th International Conference on Integrated Navigation Systems, St-Petersburg, May 28-30, 2012

[11] VTI Technologies Oy, "SCC1300 gyroscope" datasheet, *http://www.vti.fi/en*

"IRNSS is expected to be realized by 2014-15"

Says S K Shivakumar, Director, ISRO Satellite Centre (ISAC), India while sharing his priorities and views on various issues related to GNSS

What are the challenges as Director of ISAC? Would you also like to highlight your priorities?

The primary objective of ISAC is to build satellites to meet national requirement of the country in various application areas like satellite-based communication, navigation, national natural resources management, oceanography, meteorology, cartography and exploration of outer space and other planets, etc.

The major challenges today are to blend cutting edge technology development through R&D efforts with due emphasis on production of space-worthy hardware from ISAC, along with Indian industry partners.

The technology developments should lead to newer missions and need concentrated efforts to give a good shape in the areas of High power-High bandwidth(Ka-band)-multiple beams and heavier communication satellites, next generation remote sensing satellites with high stability and agility, very high resolution cameras, microwave imaging satellites, multi spectral imaging technologies, Rendezvous and Docking experiments, Inter-satellite communications links, etc. Challenges include establishment of IRNSS constellation consisting of 7 satellites for Indian Regional Navigation Satellite System and Space science missions for in-depth studies of our universe and interplanetary missions, which would provide India a pre-eminent place among space faring nations. In this regard, ASTROSAT, the first multi wavelength observatory mission, Mars orbiter mission, first mission to MARs planet, Chandrayaan-2, a follow on mission of successful Chandrayaan-1 and Aditya-1, India's first mission to study the solar coronagraph are all in the pipeline. New frontiers like Astro-biology and Material Science (space systems) require serious considerations to enable micro gravity experiments relevance to the scientists.

In the facilities front, ISAC has already established state-of-the-art facilities for building satellites. Keeping abreast with the latest technology, a world class clean room for multiple satellite integration, production facility and an end-to-end spacecraft testing has been established.

The other major challenges ahead are the total establishment of the Space Research complex, Chellakare, Chitradurga for building satellites with advanced technology.

To meet the enormous challenges ahead, we have to train and develop a new breed of talented engineers and space scientists to realize the vision of ISAC and enable them to reach new frontiers of space technology for the benefit of the nation. Finally, we have to be one among the top space faring nations in the world.

You had been associated with Chandrayaan-1 mission. Is there any plan for Chandrayaan-2?

India as one among the very few space faring nations, has made a mark in the global scenario with the success of Chandrayaan-1, the first mission to Moon. The mission has provided valuable data to the scientific community that includes the discovery of water molecule on the Moon.

Chandrayaan-2, a follow on the first mission, has been envisaged during 2014-15 timeframe. It comprises an orbiter craft & Lander along with Rover. The lander & rover craft will descend on to the terrain of the Moon, while the rover will conduct in-situ experiments on the lunar surface. In-situ analysis of lunar samples is configured to be carried out using alpha/neutron/X-ray Florescence spectroscopy. The orbiter craft is similar to Chandrayaan-1 which carries payloads like Solar X-ray Monitor, Synthetic aperture radar, Imaging IR spectrometer, neutral mass spectrometer, Terrain Mapping camera, etc. The payload/Instruments are meant for imaging, study of mineralogy, chemistry, alpha/neutron spectrometry.

What is the update on GAGAN?

After the installation, integration and testing of all GAGAN ground based elements and space segment, GAGAN Final System Acceptance Test (FSAT) was successfully completed on July 16-17, 2012. During the Final System Acceptance Test, the system performance in the integrated live environment using the satellite signals and ground based systems were validated. The FSAT results have successfully demonstrated that GAGAN Signals meets the civil aviation requirements of integrity, accuracy, continuity and availability. GAGAN signal in space is available through GSAT-8 GEO satellite with PRN127 and it is being used by non aviation users across the country. GSAT-10 with PRN128 is getting ready for launch during September 2012. The certification activities are in progress and GAGAN system is to be certified by DGCA for safety critical civil aviation applications.


TRANSFORM THE WAY THE WORLD WORKS
Don’t miss Trimble Dimensions 2012!
Join leaders in your industry at the premier conference for positioning professionals and learn first-hand what the future of positioning technology holds for you. Gain insight into how you can effectively leverage innovative solutions that are transforming the way the world works—from how highly integrated tools are changing the way surveying is performed to how construction projects are designed, executed and managed to how geospatial data is collected and analyzed for a wide range of applications.
Trimble Dimensions offers a wide range of educational and networking opportunities—with over 400 sessions from industry experts, inspirational keynote speakers, a pavilion showcasing the latest technologies, and special events to mingle with peers from around the world—learn how positioning technology is transforming the way the world works!
Register now at www.trimbledimensions.com
Trimble 2012 DIMENSIONS
November 5–7 | The Mirage | Las Vegas
www.trimbledimensions.com
©2012 Trimble Navigation Limited. All rights reserved.

How do you plan to harness the vast potential of non-aviation use of GAGAN?

GAGAN system is being established jointly by ISRO and AAI, primarily for Civil Aviation applications over India. However, it has enormous potential for non aviation users also. To create awareness among the user community and to highlight the advantages of using GAGAN signal for non-aviation purposes, a Global Navigation Satellite System (GNSS) User Meet was organized at ISRO Satellite Centre, Bengaluru, early this year. Over 250 delegates from the government, industry, academia and user community participated in the meet. The objective of the user meet was to provide a thrust in the development of GNSS-based applications and user receivers utilizing GAGAN and IRNSS navigation signals in India. The meet provided an opportunity for experts from industry, Users and service providers to interact and exchange information.

Similar meets, symposiums/workshops will be frequently organised for the user community to tap the potential of this new emerging field of navigation. An effort is on the anvil to establish a potential user group for developing GAGAN and IRNSS-based applications.

How do you plan to involve the industry for developing user segment equipment for GAGAN system?

Any GPS receivers capable of receiving SBAS signals can receive GAGAN signals and use it. GAGAN compatible receivers are already available in the market. The industry needs to produce application oriented receivers for location based services, surveying, agriculture, scientific research, Geodesy, intelligent transportation system, maritime applications, indoor application, etc. The challenge for industries is in large scale manufacture of miniaturized, robust receivers at reduced cost for various applications. ISRO is essentially a satellite service provider, but is open to interact with the industry on a case-to-case basis for technology development in relevant areas.

What is the timeline for IRNSS?

Indian Regional Navigational Satellite System (IRNSS-1), the first of the seven satellites of the IRNSS constellation is planned to be launched onboard PSLV in the first quarter of 2013. Thereafter, the rest of the 6 satellites will be launched and the full constellation of IRNSS is expected to be realized by 2014-15 timeframes.

How do you see the emergence of multi-GNSS scenario in near future?

The emergence of multi-GNSS scenario in the future is good for the user community. By using multi-mode receiver, the user need not depend on a single system. Also better accuracy, continuity and availability can be achieved by using signals from different constellations. Since various GNSS constellations are developed to fulfill their local and regional requirements, there are many systems to aid seamless navigation across the globe through interoperability. GPS and GLONASS are already operational. COMPASS, GALILEO are in various stages of development. India's IRNSS and QZSS of Japan are also coming up. In addition, the augmentation systems like WAAS, EGNOS, MSAS and GAGAN are already available to the user. While the benefits are quite significant, the associated challenges in terms of realizing common time, reference systems, code, frequency allocations, transmitted power, signal interference, etc., are yet to be resolved. These issues are however, addressed at various international forums.

What will be the significance of GAGAN once IRNSS is in place?

GAGAN is a Satellite Based augmentation system, whereas IRNSS is an independent regional navigation system. Both have their own significance.

GAGAN, being an augmentation system, supports safety of life applications. As against this, IRNSS offers PVT solutions like other GNSS. Once IRNSS is in orbit, multimode receivers capable of receiving both the signals will perform precise positioning providing m/cm level accuracies.

GNSS systems are said to be vulnerable to threats of jamming, interference and spoofing. How do you see it as a challenge and measures to counter it?

The threat to GNSS signals is similar in nature to any other RF system. For each of the interference, effective countermeasure techniques and mitigation techniques are the need of the hour. Anti Jamming techniques like adaptive filtering, antennae techniques and time-frequency domain processing are being utilized. For anti-spoofing, encryption, longer codes and implementation of pilot and secondary codes, data processing techniques are employed.

The increased usage of PPDs and other EM wave devices (intentional and non-intentional) are found to interfere with GNSS signals. While methods to mitigate these interferences are being investigated, regulatory measure also needs to be worked out.

There has been a lot of concern regarding Space Weather becoming a source for the cause of errors in GNSS systems? What is your view on it?

Space weather accounts for the most substantial errors experienced by GPS/GNSS systems and their users. It is the single largest contributor to the single-frequency GPS error budget and this needs to be estimated and accounted. Space weather predictions, better models and products/services, TEC maps over India, Ionosphere modeling, dual frequency receivers, etc., will help in mitigating the effects of the errors introduced. IRNSS is conceived as a dual frequency system and for GAGAN Grid based Ionospheric corrections are transmitted to remove the major error source of Ionospheric delay.

"GAGAN enhances reliability and reduces delays to aircraft"

V Somasundaram, Member Air Navigation Services (ANS), Airports Authority of India highlights the importance and role of GAGAN in air navigation

What are the key challenges before aviation and the role of AAI?

Considering the transformational rate of growth in passenger traffic, airline fleet and the aircraft movements anticipated in the next few decades, the challenges that confront aviation are the need for matching airport/CNS-ATM infrastructure, airport/airspace capacity enhancement and technology up gradation. Airports Authority of India (AAI) has taken a number of initiatives to upgrade the airport and airspace infrastructure to cater for the spiraling growth in air traffic, with emphasis on safety and efficiency of aircraft operations and comfort to the traveling public.

As far as Air Navigation Services are concerned, we have improved by leaps and bounds in terms of CNS-ATM infrastructure. Augmentation of radar coverage, complete automation of Air Traffic Management at major airports and implementation of data link communication are some of the major technological initiatives that we have taken up to improve operational efficiency and safety. The recent international recognition in terms of Jane's ATC award 2012 is a firm testimony to our achievements in this direction. The other major technological initiatives on the anvil are the Air Traffic Flow Management System and operationalization of the Satellite Based Navigation System of India called GAGAN.

How is GPS being integrated in the modernization of AAI's plans in aviation security and navigation?

GAGAN is designed to provide the additional accuracy, availability and integrity necessary to enable users to rely on GPS for all phases of flight, from enroute through approach for all qualified airports within the GAGAN service volume. GAGAN, through its improved positional information will be an enabler for Performance Based Navigation (PBN) and Automatic Dependent Surveillance – Broadcast (ADS-B) and Route optimization through direct routing.

It has been said that India will have certified GAGAN by 2013. How close we are to this?

GAGAN signal in space is already available. It has entered the final operational phase and on certification of the system, which is in process, the system is expected to be operational by June 2013.

Are we equipped to put GAGAN to its optimum use for air navigation?

As I mentioned earlier, GAGAN is operational and signals are already available for non-aviation use. On certification, the system will be available for aviation use for aircraft equipped with suitable SBAS receivers. As such, we are fully committed and ready to put the system in operation for aviation as per schedule.

What is your preparation to make prospective users aware about GAGAN and its applications?

A GNSS User meet was organized jointly by ISRO and AAI in which 250 delegates from the government, aviation industry and educational institutions participated. The meeting provided all the participants with an insight into GAGAN, its operation, potential areas of its application, the advantages of GAGAN, etc. Another GNSS user meet has been planned in Delhi this month. In addition, many awareness programs and interactive sessions on GAGAN have been organized as part of conferences/ seminars conducted by AAI and other aviation-related organizations.

How is the implementation of GAGAN going to be commercially beneficial for the Indian Aviation Industry?

GAGAN through improved position information permits approaches with vertical guidance, thereby improving access to the airport even during bad weather conditions and consequently reducing diversion of aircraft to other airports. This ensures fuel savings for airlines and reduction in environmental emission. GAGAN enhances reliability and reduces delays in flights, and aids passengers by defining more precise terminal area procedures that feature parallel routes and optimized airspace corridors. This again ensures considerable flight time/fuel savings and valuable man-hours contributing immensely to the Indian economy apart from environmental benefits.

How do you see the issue of interference and spoofing of satellite signals as threats for the aviation industry? Is AAI preparing for any special measures to counter it?

Unintentional interference to GNSS signals may arise from several sources, operating in the same bands as GNSS or in other bands. A non-exhaustive list would include mobile and fixed VHF communications, television signals, certain radars, mobile satellite communications, military systems, point-to-point microwave links, GNSS repeaters and systems on-board aircraft (both avionics and passenger devices).

Intentional interference to GNSS signals (jamming) so far has typically targeted non-aviation users, but it may affect aviation users as well. Presently, AAI is mitigating the effects of interference by effective spectrum management and interference tracking.

Further, International Civil Aviation Organization (ICAO), AAI, other ANSPs, standardization bodies, manufacturers and aircraft operators are also assessing the cost-benefit aspect of an effective solution to the above issues which is the use of multi-constellation, multi-frequency GNSS. As far as the interference caused by Ionospheric scintillations is concerned, the Unique IONO algorithm developed for GAGAN would address the issue to a large extent.

The ultimate goal of the industry is to establish an institutional and legal framework that would enable the unrestricted use of any GNSS element.

"The key issue in Asia is harmonization"

Miyoun (Mimi) Dobbs, Program Director – Asia Pacific, Center for Advanced Aviation System Development (CAASD), MITRE discusses the role of MITRE in GAGAN project

What key issues in Asia should be taken on priority related to air navigation?

The key issue in the region is harmonization, which is not just a regional issue but rather a global matter. Within the region, different countries are at different stages of development, from Air Traffic Management (ATM) systems to procedures and airspace designs—some are quite advanced while others are just getting started. With so many varying levels of maturity, coupled with the density of the Asia region, seamless airspace operations that will provide the maximum operational efficiency and safety to airspace users is a challenge to achieve. The priority should be to implement customer-focused services, such as Performance-Based Navigation (PBN). PBN allows for more and different services based on an aircraft's performance capabilities. In order to implement PBN, which is a mature technology available now, airspace redesign in the region must happen and India is well positioned to lead this region.

What is MITRE's role in GAGAN?

The MITRE Corporation is serving as the technical advisor for the GAGAN certification. We perform various tasks, such as evaluate monitoring algorithms, participate in Technical Review Team meetings, provide independent review of documents and offer technical support to the Airports Authority of India (AAI), Directorate General of Civil Aviation (DGCA), and the Indian Space Research Organization (ISRO). We are also helping the Indian government to develop the master certification plan and conduct operational testing and evaluation.

How challenging was it to work with GAGAN project?

The GAGAN project presents challenges specific to the region. India's atmospheric environment as a country in an equatorial region is unique and as a result there are a number of characteristics that we've not had to deal with on other Satellite-Based Augmentation System (SBAS) implementation projects. The other challenge is, of course, time: there is a lot to be done and a limited time in which to do it.

Do you also provide consultancy on non-aviation use of GAGAN?

No. Even though there are many non-aviation uses of the SBAS system, the scope of our contract with regards to GAGAN is limited to aviation. If the GAGAN system can meet the stringent aviation use requirements, it will meet majority of other user requirements.

What other SBAS systems you are/were associated with?

MITRE has supported the development and certification of the Wide-Area Augmentation System (WAAS) in the U.S. and the Multifunctional Transport Satellite (MTSAT) Satellite Augmentation System (MSAS) in Japan. WAAS was the first project of its kind to be commissioned, and we have been involved with it for almost 15 years; we have supported Japan's MSAS program for over a decade. MITRE is also involved in GPS modernization projects. In addition, we actively participate in forums involved in SBAS interoperability and International Civil Aviation Organization (ICAO) standardization.

In the context of users of SBAS, do you think that issues related to privacy and sovereignty will also have to be dealt with?

Yes. SBAS provides services beyond the boundaries of the country (or, in the case of Europe, multi-state organization) that owns and operates the system. So how those services are shared or controlled will depend upon the relationships among the neighbouring countries. States must approve GNSS navigation in their airspace; so any country that is within the footprint of SBAS service would have to approve of its use. However, if they do not control the signal-in-space, they may be hesitant before accepting the liability they would automatically accept when approving the use of this signal-in-space. So, the main issues are sovereignty and liability. The ICAO vision is that all states would approve GNSS-based navigation without restriction regarding the source of the service. Some within ICAO are concerned about the risk that, for political reasons, one or more states might mandate a particular GNSS solution while disapprove the use of another. This could create a difficult situation for airlines because of the potential cost and complexity of carrying different avionics for different airspaces.

In terms of privacy, just as GPS functionality can be embedded in devices used to track the location of various modes of transportation (e.g., trucks, cars) and cell phones, SBAS functionality can too. SBAS is also susceptible to the same types of signal interference (intentional or unintentional) from jammers or industrial or military test activities. That said, the benefits of a system like SBAS are numerous.

Visit us Sept. 17-21 @ ION GNSS | Booth 226

Visit us Oct. 9-11 @ INTERGEO
Hall 9 | Stand H.64

The Power of RTK level accuracy backed up by StarFire

Our LAND-PAK complete survey system offers the power of RTK level accuracy with the added benefit of 5cm global accuracy when RTK corrections are not available. With StarFire GNSS, users can now achieve 5cm accuracy worldwide, without a base station. For applications that require RTK accuracy, the LAND-PAK system is built around a powerful combination of advanced survey tools that also helps reduce communication outages while providing extended coverage with Ultra RTK & RTK-Extend™.

We understand that to do the job right, you need all the right tools. The LAND-PAK system includes full GNSS support, an online video training library, all hardware & accessories, plus field, office & GNSS post processing software. For additional piece of mind, LAND-PAK is covered by our industry leading three year warranty.

LAND-PAK is your more complete survey system, with all the right tools to get the job done right.

www.LAND-PAK.com

NAVCOM
A John Deere Company

GAGAN: Status and Update

The Final System Acceptance Test (FSAT) was completed during July 2012 and the GAGAN signal in space is evaluated using SBAS receivers at various locations across the country

A S Ganeshan
Project Director,
Navigation Systems,
ISRO Satellite Centre
India

The GAGAN (GPS Aided Geo Augmented Navigation) system is a planned implementation of a Satellite Based Navigation System (SBAS) jointly developed by Indian Space Research Organisation (ISRO) and Airports Authority of India (AAI), to deploy and certify an operational SBAS over Indian Flight Information Region. When commissioned for service, GAGAN will provide a civil aeronautical navigation signal consistent with International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPS) as established by the GNSS Panel. ICAO endorsed GNSS as Future Air Navigation systems (FANS) for civil aviation.

GAGAN coverage

GAGAN GEO footprint

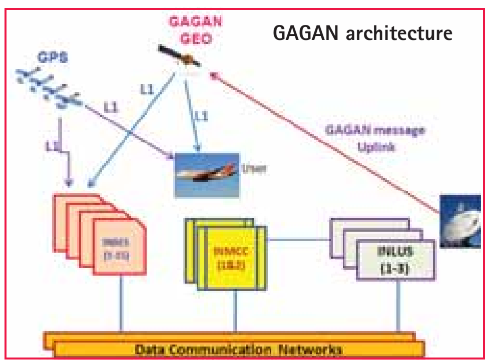
The project involves the establishments of a full complement of SBAS consisting of 15 Indian Reference Stations (INRES), 3 Indian Land Up-link Stations (INLUS), 2 Indian Master Control Centers (INMCC), 2 Geo-Stationary Navigation Payloads and with all the associated software and communication links.

GPS satellites' data is received and processed at widely dispersed Indian Reference Stations (INRESs), which are strategically located to provide coverage over the required service volume. Data is forwarded to the Indian Master Control Center (INMCC), which processes the data from multiple INRESs to determine the differential corrections and residual errors for each monitored GPS satellite and for each predetermined Ionospheric Grid Point (IGP). Information from the INMCC is sent to the INLUS and uplinked along with the GEO navigation message to the GAGAN GEO satellite. The GAGAN GEO satellite downlinks this data to the users via two L-band ranging signal frequencies (L1 and L5), with GPS-type modulation.

Combination of Terrestrial and VSAT communication links are being established between INRES and INMCC sites as a back-bone network by AAI. An iono model called IGM-MLDF (ISRO GIVE Model-Multi Layer Data Fusion) developed by ISRO is incorporated in the INMCC operational software to represent the ionosphere variation, both spatial and temporal, over Indian region. On installation, integration and testing of the ground elements and integration with GSAT-8 GEO satellite, the GAGAN signal-in-space, available since December 2011, is for non-aviation users such as survey, geodynamics, road and rail applications, vehicle tracking, intelligent traffic systems, land management, scientific research and maritime applications, etc.

The FSAT was completed during July 2012 and the GAGAN signal in space is evaluated using SBAS receivers at various locations across the country and the system performance was verified. SBAS user receivers were deployed at various locations within India, and the performance in terms of accuracy and integrity were monitored and were found to be within specifications. The second GEO satellite GSAT-10 will be launched in September 2012 and integrated with 2nd INLUS at Bengaluru. The third INLUS located at New Delhi, will serve as a redundant system to the 1st INLUS at Bengaluru for GSAT-8 GEO satellite. As the system is ready for certification by DGCA, the data from all the INRES are being collected and processed to study and analyze the occurrence of any HMI (Hazardously Misleading Information) in the user received signal. A Technical Review Team (TRT) has been formed by the DGCA to review the system performance in terms of integrity and other factors to be compliant with ICAO requirements.

GSAT-8 is providing GAGAN signal at PRN-127, while GSAT-10 will provide GAGAN signal at PRN128. GSAT-15 will serve as an in-orbit spare once it is launched in the near future. In realizing the SBAS services over Indian region, AAI has initiated several activities such as development of SBAS procedures for a few identified airports, holding stake holders meeting, flight testing of GAGAN SIS through calibration aircraft, etc., so that GAGAN certification can be completed by the third quarter of 2013.



GAGAN architecture

J-Shield

You can either hope that interferences will never happen; or get a GNSS receiver that has protection against interferences.

You can either hope that special interest groups, and Coalitions, who cannot build a good filter, will always be successful in lobbying to offer mediocre technology, keep the precious bands near GNSS wasted and prevent systems like LightSquared authorization, or get a GNSS receiver that has protection against such systems while offering better performance too.

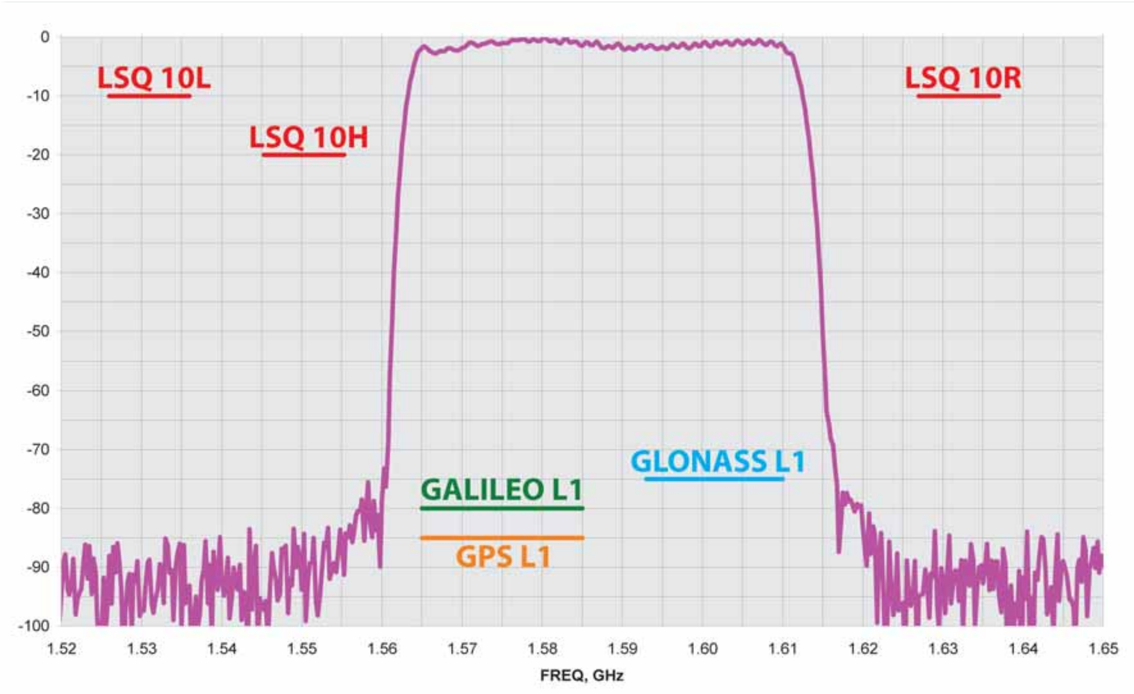
The United States of America is currently ranked 16th on broadband wireless connectivity. We are proud that our technology not only protects and improves the performance of the GNSS system, but also helps to support proper usage of the precious bands to improve broadband wireless communication and reduce user costs to 1/3 of what is today.

You can either trap yourself by owning defective GNSS receivers which forces you to support coalitions preventing progress of wireless broadband in the United States, or you can own a GNSS receiver that performs better, has protection against such interferences and frees you from such political games.

Our team has been bringing you the latest GNSS technology for the past 30 years. We were working on defending against in-band and out-of-band interferences ten years before the LightSquared issue surfaced.

You can either listen to some folks who do not have sufficient knowledge about GNSS technology, but give advice and testimony to Congress, or analyze the technical details that we present in the next few pages which are backed by our GNSS receivers in mass production today.

J-Shield ....



A good GNSS receiver should bring in ALL of wideband GNSS signals and reject all other unwanted signals. We announced the existence of this technology months ago for the L1 band. Now we have improved this filter and added similar protection for all other GNSS bands.

The figure above shows the frequency response of our filter for L1. As shown in this figure, it allows complete, undisturbed L1 signals in and defends against any other signals outside this band. In particular it defends against LightSquared signals of 10L, 10H, and 10R (Handsets). The filter drops down quickly, at the rate of 12 dB/MHz outside the GNSS band.

Figure on the right shows the frequency response of our filter for other GNSS bands. Although there are no requests for other systems near these GNSS bands yet, our filters have protection if this happens in future.

Interference is not limited to wideband wireless systems. Harmonics of other transmitters can occur anywhere and we see it as an essential requirement to protect all GNSS bands in our receivers against all interferences as much as possible. Our technology allows us to do a better job today.

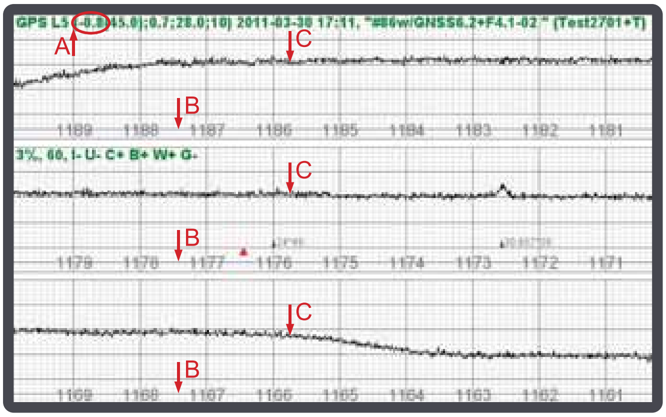
Our effort in protecting the GNSS bands did not end with designing appropriate filters. We needed to a) prove that these filters work, b) prove that these filters not only do not degrade the performance of GNSS receivers but improve performance, c) devise features that any person can use to test our receivers, and d) devise features where users can readily see the effect of interferences that may fall within the GNSS bands in some areas or see the effect of intentional jammers that are marketed these days with prices as low as $400.

So, how to recognize interferences and how to quantify their effects?

Interference Analyzer ...

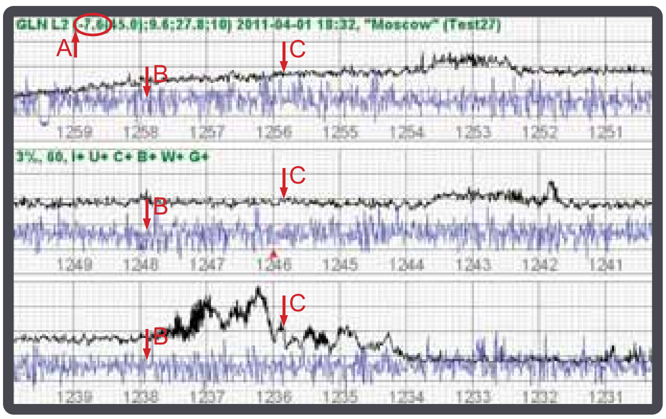
Click the "Spectrum" icon on the Home page to see the vast amount of information on interferences. See www.javad.com for details of screens which follows.

Next to the "Spectrum" icon is the "Cycle Slip" icon which is discussed later.

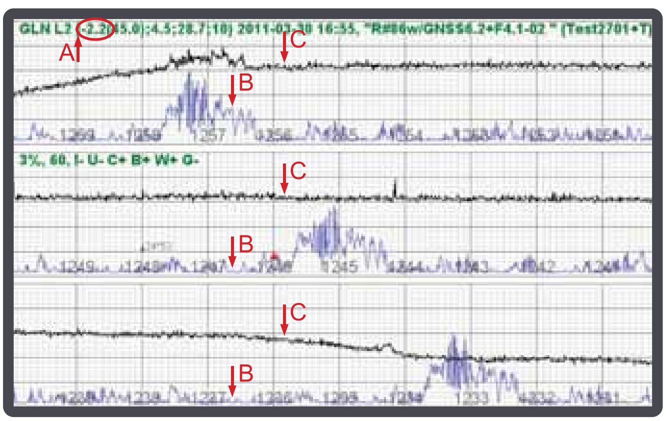


Numbers marked "A" on top left of the spectrum screens show the power of interference. The interference may be in-band or out-of band or a very wide "white noise".

The shape of the spectrum (marked "C") shows the location of in-band interference.



We have assigned 60 of our 216 GNSS channels to monitor the 6 GNSS bands and report interferences in four different ways. You can check interferences in your environment before starting your job to ensure your environment is clean.

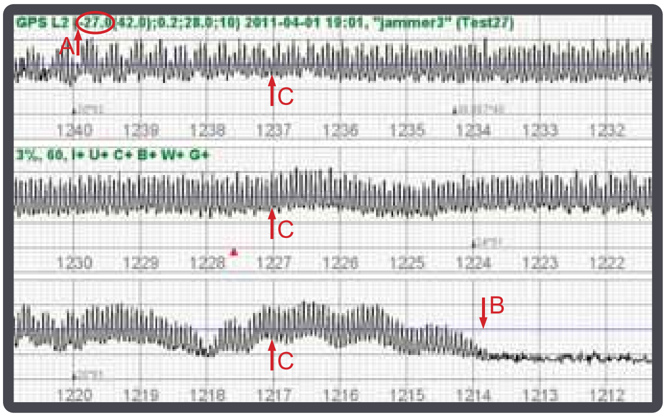


The blue line (marked "B") is the control voltage and fluctuations there shows the presence of unwanted signals with some visual quantification.

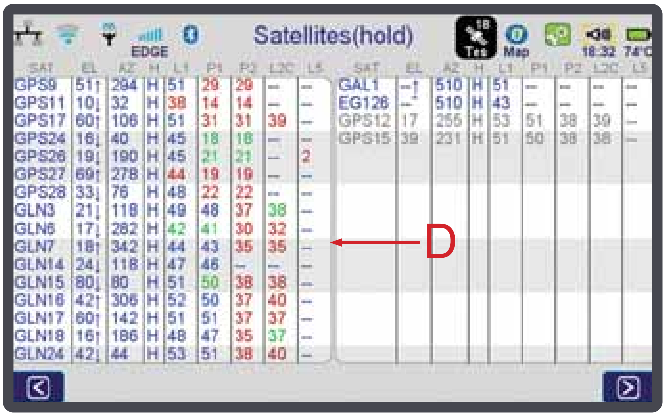
First screen shows no interference and the two figures below it show some interference as shown by A, B and C designations.

... Monitoring/quantifying Interferences

In this figure the band has been completely jammed by a $400 jammer.

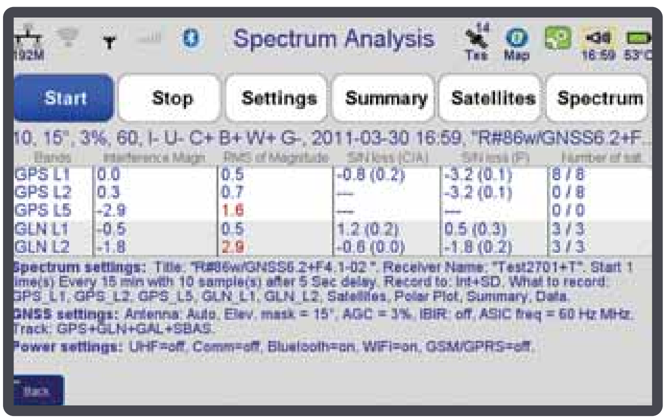


This figure shows color coded satellite signal strength after signal processing. Blue: Perfect, green: 3dB less, red: at least 6 dB less.



This figure shows the same color coded information in polar coordinates of satellites. This helps to verify if satellites have been blocked by obstruction(s).

This figure shows the summary of the spectrum analysis before and after the signal processing. See details in a 22-minute video at www.javad.com in "video lesson" section.



Real-Time Cycle Slip Detection...

SNR	Nsat	Nsat aver	Sat, %	Timei	Nslip	Nslip aver	Slip / hour
50	5	5.22	35.88	10800	0	0.00	---
45	8	6.55	45.00	10798	1	0.15	0.05
40	0	2.79	17.79	10026	0	0.00	---
35	0	1.10	1.32	1890	0	0.00	---
30	0	1.00	0.00	1	0	0.00	---
25	0	0.00	0.00	0	0	0.00	---
20	0	0.00	0.00	0	0	0.00	---
0	0	0.00	0.00	0	0	0.00	---

Tracking and measuring carrier phases of satellites are the foundation for all GNSS precision applications. This is why high precision GNSS receivers are much more complicated and more expensive than low precision receivers which only measure code phases. Any internal deficiency in design and/or manufacturing of high precision GNSS receivers; or the effect of any external phenomena (like interference and multipath) can cause carrier phase tracking to jump from one cycle of carrier to another. This is called carrier “Cycle Slip”. You may call it missing a “heartbeat”.

Unlike “loss of lock” which is obvious to detect, carrier cycle slips may have no apparent effect on satellite signal tracking and producing navigation solutions. They can be discovered and repaired in post processing software or in RTK engines after enough data is processed. Erroneous results in high precision solutions (post processed or RTK) are the result of undetected cycle slips.

If the ultimate objective of any high precision receiver is to track carrier phases of satellites correctly, it is highly desirable that any test that is intended to monitor the effect of interferences of other signals on GNSS, should also focus on monitoring and quantifying cycle slips. It is much like monitoring the “heartbeat” of a GNSS receiver in real-time.

We are proud to announce that we have been able to provide this feature in our GNSS receivers and monitor cycle slips in real-time as the ultimate way to determine the quality of a GNSS receiver and the effect of interferences.

Part of our confidence in the excellent performance of our J-Shield filters is based on monitoring the heart beat and observing that J-Shield does not cause even one cycle slip after 24 hours of tracking. Not even missing one “heartbeat” in 24 hours!

An interesting feature of our innovation is that it is available in our GNSS receivers and users by a simple click can access screens and features that we are going to explain next.

... Monitoring the "Heartbeat"

SNR	Nsat	Nsat aver	Sat, %	Timei	Nslip	Nslip aver	Slip / hour
50	0	1.00	0.24	372	0	0.00	---
45	2	3.31	22.73	10802	0	0.00	---
40	9	3.96	27.24	10799	0	0.00	---
35	0	3.49	23.84	10728	1	0.29	0.10
30	1	2.11	12.87	9593	0	0.00	---
25	1	1.79	10.40	9149	0	0.00	---
20	0	1.13	2.17	3019	0	0.00	---
0	0	1.00	0.51	805	0	0.00	---

Figure above shows the cycle slip screen which is updated every second and records the number of satellite cycle slips grouped according to their signal strengths.

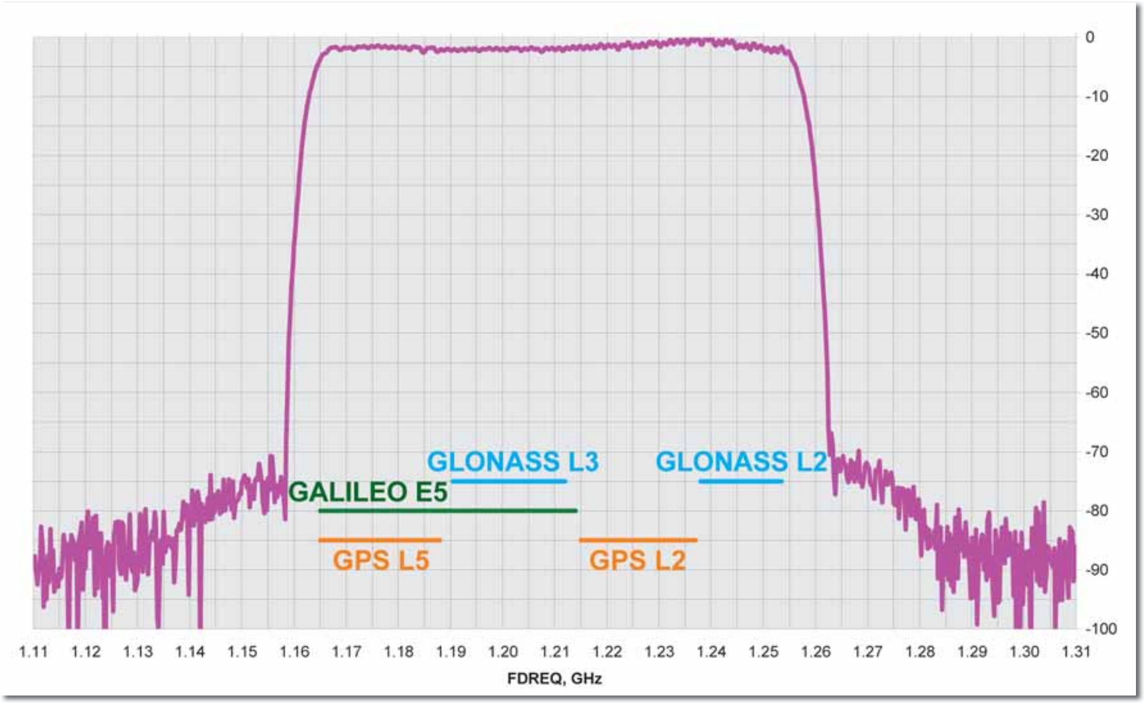
Col 1 (SNR) is the signal strength of satellites grouped from 0 to above 50 dB/Hz. Col 2 (Nsat) is the current number of satellites with strength in each bin. Col 3 (Nsat aver) is the average number of satellites with strength in each bin since test started or reset. Col 4 (Sat %) is the percentage of satellite signals in each bin during test period. Col 5 (Timei) is accumulative time that any satellite has strength in that bin. Col 6 (Nslip) is the total number of cycle slips form all satellites during the test period. Col 7 (Nslip aver) is the average number of cycle slips per satellites during the test prior. Col 8 (Slip/hour) is the average number of cycle slip per satellite per hour during the test period (N/A is shown during the first 30 minutes).The number on the top left (10800) is the elapsed time since test started. The number on the top next to it (47.65) is the average of all satellite signal strengths during the test period. Reset button restarts the test; Reset Period selection option restarts test automatically after this elapsed test time; and Make snapshot checkbox records this screen after each test period (if checked). L1 and L2 buttons select screens for L1 and L2 signals.

Figure on the right side shows similar items for the L2 band. Note that the average signal strength of the L2 band is about 9 dB less than the L1 band (47.65 - 38.57). This is because the GPS L2 signals are encrypted.

With comprehensive test features that we have embedded in our receivers users can monitor the environment and gain detailed information about possible interferences and their spectral characteristic. They can also look at the heartbeat of a receiver by looking at the cycle slip screen.

All such tests are being performed in the background without any interruption to the normal operation of the receiver in performing survey and RTK tasks.

... For All GNSS Bands



Without proper equipment and knowledge any technical issue can turn political and lobbyists, politicians, bloggers and editors will take over and stars of generals and titles of people will eclipse the scientific facts.

To study the effect of interferences in some official tests, they had to use very expensive equipment in highly sophisticated laboratories, employ experts, and then wait for several weeks to get the test results. These results were not conclusive and therefore were open to interpretation.

It is our claim that these new innovative test features that we have embedded in our GNSS receivers a) are much more comprehensive than those done in laboratories with a roomful of equipment, b) can be used by any novice user in the field, and c) provide instantaneous results.

The embedded features perform five different highly sophisticated tests and show the results automatically in a user friendly and easy way. A push of a button activates all these tests in the background while user can perform their normal survey or other positioning tasks.

For each GNSS band we have embedded features to **A)** quantify interferences by AGS numbers, and its variations, **B)** visualize interferences by the AGC control voltage graph, **C)** visualize and quantify in-band-interferences by the spectrum graphs deep inside the signal processing section, **D)** show deviations of C/N0 from standard numbers, **E)** measure and show any missing ‘heartbeat’ inside the carrier phase tracking system with our new sophisticated and comprehensive real-time cycle slip indicator.

The next four pages (inside) are dedicated to brief explanations of these subjects.

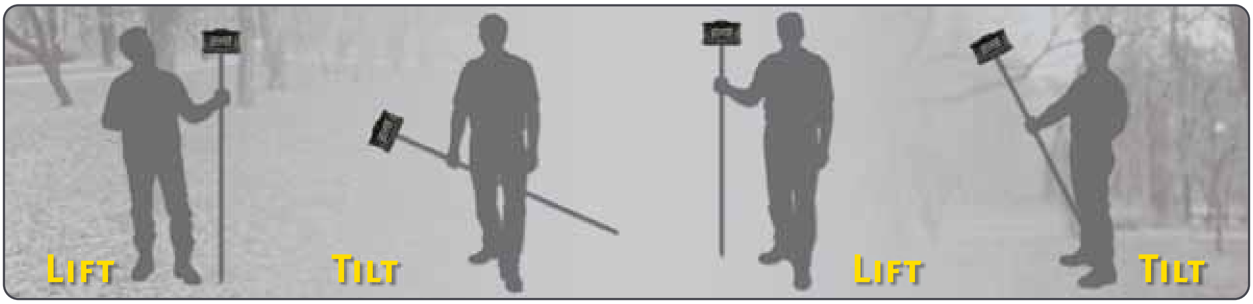
Six Parallel RTK Engines

Each of our 6 parallel RTK engines employs different algorithms to calculate solutions and the weighted average of them provides robust, accurate, and fast results.

Visual Stakeout

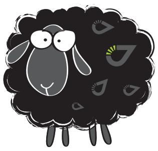
Visual Stakeout (VSO) is a convenient extension of the regular stakeout procedure. VSO makes it easier to find the target point in the field displaying the point on a special augmented reality screen which can be accessed during a regular stakeout process.

Lift&Tilt



It seems TRIUMPH-VS reads your mind! Many sensors, intelligence, and innovations inside TRIUMPH-VS bring this new revolution to surveyors.

You don't need to look. You don't need to touch.



BeiDou will enhance the comprehensive national strength of China

Xingqun ZHAN, Professor of Guidance, Navigation and Control at School of Aeronautics and Astronautics, Shanghai, China discusses the benefits, services and future plans of the BeiDou system

What is the origin and meaning of BeiDou?

BeiDou is the Chinese pronunciation of the Big Dipper, which consists of seven stars located exactly at the north sky. Chinese people used BeiDou for identifying directions as long back as the ancient times. They also invented the world's first navigation device based on terrestrial magnetism, the ancient compass, whose Chinese pronunciation is Sinan. Today, BeiDou will continue serving people from China and all over the world not only on navigation, but also on positioning and timing. The BeiDou system will meet the demands of China's national security, economic development, technological advances and social progress, safeguard national interests and will enhance the comprehensive national strength. Meanwhile, it will provide stable, reliable and quality satellite navigation services for global users along with other Global Navigation Satellite Systems.

How has been the performance of the system so far?

BeiDou Initial Operational period provides services to China and most parts of its surrounding areas covering from 84E to 160E, from 55S to 55N. A number of field tests have been carried out, showing that, the user receiver positioning accuracy is 25m horizontally and 30m vertically. Its velocity accuracy is 0.4m/s and timing accuracy is 50ns. Besides, BeiDou Initial Operational period retains the active positioning and short message services from BeiDou Demonstration System.

What are the major application areas of BeiDou?

The BeiDou Demonstration System has been widely used in transportation, marine fisheries, hydrological monitoring, weather forecasting, forest fire prevention, timing for communication systems, power distribution, disaster mitigation, national security, and many other fields. Upon the full operation, BeiDou will provide more high-performance services for civil aviation, maritime, rail, finance, postal, land resources, agriculture, tourism and other industries.

How many satellites have been launched and how many are planned for this year?

By the end of April 2012, 13 BeiDou satellites have been launched and formed a basic system. The launch of two MEO and one GEO BeiDou satellite have been planned for this year. By then, the BeiDou regional service will be formally provided.

How is rest of the world going to be benefitted from BeiDou?

From December 27, 2011, the BeiDou Initial Operation Service and the following BeiDou Regional Service have been covering most of the surrounding areas of China. Chinese government promotes international cooperation on BeiDou regional and global applications. Multi-GNSS applications based on a BeiDou user terminal compatible and interoperable with other satellite navigation systems are also encouraged. China is actively promoting BeiDou Application Demonstration & Experience Campaign program (BADEC) in Asia and Pacific areas. The main purpose of BADEC is to spread awareness about BeiDou's real performance for local communities and promote multi-GNSS applications. This program invites a wide participation from countries the world over.

What is your opinion about interoperability ?

Interoperability is the ability of open services of multiple satellite navigation system to be used together to provide better capabilities at the user level than would be achieved by relying solely on one service, without significantly increasing the complexity of receivers. From my understanding, interoperability is to coordinate a common signal architecture and time/space reference frame that simplifies the multi-GNSS receiver as much as possible.

How do you look at the issue of jamming?

Jamming is normally an intentional interference with on GNSS signal in space. It is because the signal is too weak, which results in serious influences especially for applications relying on GNSS. Much work shall be done simultaneously. One is investigation of related laws and regulations, such as FCC on LightSquared issues in USA. Another is anti-jamming technology development not only on receivers but also on the system architecture. Some novel technologies are being developed on the frame of Interference Detection & Mitigation (IDM) and Vulnerability Monitoring which focus on the Environment Segment.

"BeiDou system will focus on compatibility and interoperability with other GNSS"

YANG Dongkai, Dr Professor, School of Electronic and Information Engineering, Beihang University, China explains the applications and the advantages of BeiDou system

What are the main application areas for BeiDou System?

Since the BeiDou Navigation Satellite Demonstration System was officially brought into service in 2003, China has achieved remarkable progress in the field of theoretical study, technology R&D, receiver production, application and service development. Along with the construction of the BeiDou Navigation Satellite System and the development of RNSS services, China has made breakthrough in multi-mode chips, antenna and receiver boards, which are compatible with other navigation satellite systems. This led to advances of independent intellectual property rights and product industrialization.

The BeiDou Navigation Satellite Demonstration System has been widely used in transportation, marine fisheries, hydrological monitoring, weather forecasting, forest fire prevention, timing for communication systems, power distribution, disaster mitigation, national security and many other fields, which has been resulting in significant social and economic benefits. Particularly, the system has played an important role in the South China frozen disaster, earthquake relief in Wenchuan, Sichuan Province and Yushu, Qinghai Province, the Beijing Olympic Games and the Shanghai World Expo.

Upon the full completion, the BeiDou Navigation Satellite System will provide a better high-performance positioning, navigation, timing and short-message communication services for civil aviation, shipping, railways, finance, postal, land resources, agriculture, tourism and other industries. In addition, the BeiDou signal (including reflections) would be useful in the fields of atmosphere detection, meteorology prediction, crust distortion monitoring, mud avalanche monitoring, etc.

> China has made break through in multi-mode chips, antenna and receiver boards. This led to advances of independent intellectual property rights and product industrialization

Is the BeiDou system competing with other existing GNSS?

As a global navigation satellite system compatible with other navigation satellite systems worldwide, i.e., American GPS, Russian GLONASS and European GALILEO system, the BeiDou system is independently established and operated by China. The BeiDou system could be used for users across the globe and its open service is free of charge. Generally, GNSS providers are encouraged to make full use of positioning, navigation and timing service in the lives of people and for industries. At the same time, the customers usually consider multiple GNSS to promote its performance when they select the systems.

What are the co-operation areas for the BeiDou system with other GNSS?

In the multi – GNSS age, the BeiDou Navigation Satellite System will carry out active and pragmatic international exchange and cooperation. This will be in line with China's foreign policies, focusing on China's basic tasks and strategic objectives for the construction of navigation satellite systems, utilizing domestic and international markets and resources in a coordinated way.

Under the framework of International Telecommunication Union (ITU), China started the BeiDou Navigation Satellite System frequency coordination activities with other GNSS. And as the core provider and member of International Committee on Global Navigation Satellite Systems (ICG), the BeiDou system has carried out extensive exchange and cooperation with other GNSS, focusing on compatibility and interoperability.

China encourages and supports domestic research institutions, industrial enterprises, universities and social organizations, under the guidance of the government policy, to carry out international exchanges, coordination and cooperation activities with other countries and international organizations in the fields of the compatibility and interoperability, satellite navigation standards, coordinates frame, time reference, application development and scientific research. China actively promotes BeiDou Application Demonstration & Experience Campaign (BADEC), International GNSS Monitoring & Assessment Service for OS (iGMAS) and other projects, develops navigation satellite technology and enhances system service performance.

What are the advantages of the BeiDou system?

The BeiDou system comprises three major components: space constellation, ground control segment and user terminals. The space constellation consists of five GEO satellites and 30 non-GEO satellites. The non-GEO satellites include 27 MEO satellites and three IGSO satellites.

The BeiDou system will meet the demands of China's national security, economic development, technological advances and social progress, safeguard national interests and will enhance the comprehensive national strength. Along with other GNSS providers, the BeiDou system will jointly promote the development of satellite navigation industry, contribute to human civilization and social development, serve the world and benefit mankind. The BeiDou system can provide positioning, velocity measurement and one-way and two-way timing services to worldwide users. It can also provide wide area differential services with the accuracy better than 1m and short messages services with the capacity of 120 Chinese characters each time.

How do you see the future of satellite navigation market?

The satellite navigation market volume is larger as its service performance is better. As multi-GNSS could provide higher accuracy, availability and more stable signal source, many new application areas and application modes help to increase the satellite navigation market.

On the other hand, the requirements from humanss such as traveling, transportation, indoor positioning, search and rescue are becoming an essential in improving the working efficiency, decrease the traveling cost and improving the life environment, etc. In addition, the combination of satellite navigation and mobile communication will enlarge and promote further the application market.

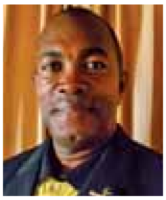
How to evaluate the problem of interference and jamming?

Satellite navigation system is basically a radio system and based on wireless transmission link so it has congenital vulnerability from the interference on the navigation radio signal. The cancellation of interference could not be done 100% theoretically as the interference problem coexists with the satellite navigation system itself. However, the interference mitigation could be done through the integration of multi-GNSS to some extent. In recent years, the GNSS providers proposed the interference detection and mitigation (IDM) based on the joint effort to improve the user service performance and discussed as an important topic in ICG meeting.

With the technology progress, the satellite signal will become more and more stable and the detection capability for the interference will become stronger and stronger. The influence on GNSS from interference would be controlled to the acceptable range for users.

The Jamaica VRS and Cadastral Surveying

This paper provides a history of the Jamaica Geodetic infrastructure and the changes that have taken place with this network over the last few decades. Readers may recall that we published the first part of the paper in August issue. We present here the concluding part



Glendon G Newsome
Senior Lecturer, University of Technology, Jamaica

Gregory Peake
Lecturer, University of Technology, Jamaica

Romayne Douglas
Graduate, Bachelor of Sciences Degree programme in Surveying and Geographic Information Sciences, University of Technology, Jamaica

Field tests

As part of our research activities at the University of Technology, Jamaica, various field tests on the system were carried out, so as to provide enough information to analyse whether the geodetic control can be an adequate integrity monitor and how well the VRS is adaptable to cadastral surveying.

GNSS Calibration Network Stations

Seven (7) of the nine (9) points which constitute the National GNSS Calibration Network were occupied using an active VRS receiver. This network of points will form the basis of legal traceability for Cadastral Surveys in Jamaica. The tables 4 and 5 below set out the results.

The results obtained from the National GNSS Calibration Network observation provided satisfactory results and were of high quality as the differences in horizontal distances ranged from 0 millimetres over a distance of 41.073 to 11 millimetres over a distance of 196.242 meters. The proportional accuracy (1/17,840) is low, due to the line being very short. The differences in the orientation were minimal and ranged from 1 second of arc (1”) to 11 seconds (11”).

The differences in the co-ordinates displayed consistency around the 5cm level in the northings for all points when compared with the known co-ordinates obtained from the Survey and Mapping Division of the National Land Agency (SMD_NLA), Jamaica. However the eastings differences fared better at the 2 cm level.

Kingston's Densification Network Stations

Two (2) points which are part of the densification of the national control network in the City of Kingston, were occupied. The tables 6 and 7 below show the results.

The Point KG53 exhibited differences of less that 10cm. However KG52 exhibited 0.589m in northing which suggest the presence of a source of significant error in the determination of these coordinates. This could have been the result of multipath due to the passing traffic, as both stations are sited in sidewalks. KG53 was also partially covered by the foliage of a nearby tree. Data logging was still possible as the receiver maintained lock and carried out recorded data. However, warnings of poor satellite geometry were being received through the TCS2 Controller. This case underscores the need for a clear and unobstructed “view” of the sky for the location of GNSS control stations if optimum GNSS results are to be realised. It should be noted however that these points were established by Total Station Traversing and not for use with GNSS.

University of technology control network stations

Three (3) of the twenty-eight (28) control stations on the campus of the University of Technology (UTech), which forms a reference network that allow student to geo-reference their surveys and provide a means of checking the accuracy of their work, were observed using an active VRS receiver in order to evaluate the accuracy of the VRS in this type of environment

HI·TARGET

V30 Original Integrated Transmit-Receive RTK

International advanced PCC BD970 motherboard
Built-in Transmit-Receive UHF
1+X Multi-Module Communication Units
Configured with PCC radio
Super long distance external radio optional

Unique Panel Design
International advanced PCC BD970 motherboard
Built-in Transmit-Receive UHF

1+X Multi-Module Communication Units
Configured with PCC radio

Own Portable Controller
Compatible with carlson software

Hi-Target Surveying Intrument Co., Ltd

www.hi-target.com.cn
www.gnss-gps.com

ADD:10th Floor,ChuangxinBuilding,Tian'an Technology Zone, No.555, North of PanyuRoad,PanyuDistrict,511400, Guangzhou City,china Tel:+86-20-22883930 Fax:+86-20-22883900 E-mail:info@zhdgps.com
Leo Chen（Europe） Tel：+86-20-22883933 E-mail：leochen@zhdgps.com
Tracy Li（South America） Tel：+86-20-22883917 E-mail：tracyli@zhdgps.com
Kelly Liang（Asia） Tel：+86-20-22883735 E-mail：kellyliang@zhdgps.com
Michael Lei（Africa） Tel：+86-20-22883960 E-mail：michaellei@zhdgps.com
Grace Zhang（CIS） Tel：+86-20-22883932 E-mail：gracezhang@zhdgps.com

Table 4: Co-ordinate differences between known, 5 epoch and 180 epoch observations

Coordinate Differences		
	N	E
5 epoch	0.0515	0.0209
180 epoch	0.0515	0.0159
5 epoch	0.0522	0.0205
180 epoch	0.0492	0.0175
5 epoch	0.0598	0.0207
180 epoch	0.0608	0.0207
5 epoch	0.0459	0.0305
180 epoch	0.0469	0.0305
5 epoch	0.0458	0.0234
180 epoch	0.0458	0.0224
5 epoch	0.0588	0.0159
180 epoch	0.0558	0.0139
5 epoch	0.0512	0.0233
180 epoch	0.0522	0.0223

Table 5: Differences in Bearings and Horizontal Distances

Bearing and	Distance Differences
0° 0’ 4”	0.000
0° 0’ 11”	0.001
0° 0’ 1”	0.011
0° 0’ 3”	0.006
0° 0’ 7”	-0.009
0° 0’ 7”	0.000

Figure 5: Occupation of a National Network Densification Station

characterized by a high density of concrete canopy. Distances were computed in order to compare the known distances with their observed values. Control Stations UT09, UT25A and UT27 were those used.

There was a negligible difference between the 5 epoch observation and 180 epoch observation. The differences between the known and measured VRS co-ordinates were in the range of -0.166 m in Northings and 0.139 m in Eastings. UT09 exhitbited a 10m bias in elevation. This indicates a blunder in conversion of the GNSS ellipsoidal height to Geoidal height. The height differences exhibited by the other stations are expected, as the geoidal model (CARIB97) that is currently in use, is not dense enough to provide good quality mean sea level elevations across the island. Differences of up to 2.5m have been reported by GNSS users on the island. There is a need for a more accurate local geoid model. The distances differed

Table 6: Co-ordinate differences between known and 180 epoch observation

Course	Bearing and	Distance Diff
KG52 - KG53	0° 6’ 25”	0.138

Table 7: Difference in azimuth and distance

Points	N	E
KG53	0.083	-0.011
KG52	-0.589	0.002

Figure 6: Occupation of a UTech Reference network station

by between 3.7 mm and 31.1 millimeters, with resulting proportional accuracies of between 1/3,800 and 1/47,300. This site is well populated with buildings and trees that would have had a negative impact on the quality of these results.

Rural Parcel

Boundary points previously surveyed by conventional means in the rural area of Kitson Town in the parish of Saint Catherine, were occupied using a VRS reciever. Approximately 30% of the boundary marks enjoyed a reasonably open view of the sky. This allowed for uninterrupted data logging to take place. The remaining points were covered by tree canopy which allowed for partial visibility of the sky. This allowed for observations to take place, but with frequent warnings of poor satellite geometry received through the TCS2 data collector. All of the marks were observed and in quick succession of each other. The survey (measurements aspect) lasted for approximately 15-20 minutes, compared to the hour or so it took to traverse and take side shots to the boundary points. In a Total Station survey,

Table 8. Co-ordinate differences between known, 5 epoch and 180 epoch observations

Diff N	Diff E	Diff H
5 Epochs		
0.131	0.139	10.844
0.142	0.135	1.089
0.162	0.12	1.061
180 Epochs		
0.124	0.139	10.834
0.135	0.132	1.109
0.166	0.123	1.061

Table 9: Distance differences between known, 5 epoch and 180 epoch observations

5 Epochs		
Distance	Diff	Accuracy
176.078	0.006	1:31,000
181.135	0.014	1:13,300
120.911	0.025	1:4,800
180 Epochs		
Distance	Diff.	Accuracy
176.080	0.004	1:47,300
181.130	0.009	1:20,100
120.918	0.031	1:3,800

Table 10: Differences in Bearings and Horizontal Distances in Kitson Town Survey

Courses	Bearing and	Distance Differences	Accuracy
1 – 2	0° 0’ 11”	0.035	1:550
2 – 3	3° 28’ 45”	0.119	1:43
3 – 4	1° 24’ 36”	-1.803	1:19
4 – 5	2° 27’ 39”	0.672	1:41
5 – 6	0° 0’ 0”	0.143	1:323

Table 11: Differences Bearings and Horizontal Distances in Urban Survey

Courses	Bearing and	Distance Differences	Accuracy
2 –1	0° 00’ 00”	-0.012	1:10,123
2 – 3	1° 08’ 00”	0.008	1: 2,938

Figure 7: Occupation of a boundary point on a parcel in an Urban part of St. Andrew

Figure 8 : Occupation of a boundary point on a parcel in an Urban part of St. Andrew

Table 12: Differences in Bearings and Horizontal Distances in Sydenham Subdivision

Lot 257			
Courses	Bearing and	Distance Differences	Accuracy
1 – 2	0° 5’ 22”	-0.225	1:109
2 – 3	0° 9’ 49”	0.033	1:414
3 – 4	0° 13’ 13”	-0.153	1:160
4 – 1	0° 8’ 8”	-0.033	1:416
Lot 384			
1 – 2	0° 1’ 38”	-0.015	1:945
2 – 3	0° 1’ 49”	-0.145	1:169
3 – 4	0° 48’ 12”	-0.032	1:301
4 – 5	5° 3’ 48”	-1.813	1:3
5 – 1	1° 22’ 28”	0.654	1:30
Lot 366			
1 – 2	0° 1’ 38”	-0.015	1:944
2 – 3	1° 20’ 18”	-0.145	1:168
3 – 4	5° 23’ 4”	-0.032	1:300
4 – 5	1° 45’ 9”	-1.813	1:3
5 – 1	2° 16’ 40”	0.654	1:30

lines of sight are required between successive traverse stations, traverse stations and boundary points as well as between boundary points.

Only one line (1-2) achieved the minimum standard (1:500) required under the Land Surveyors Regulations. This demonstrates that a site with similar characteristics to this one will be unsuitable for Cadastral Surveying using VRS.

Urban Parcel

In carrying out observations on a parcel in an Urban part of the parish of Saint Andrew, only seven (7) of the fourteen (14) boundary marks that were present on the site were occupied using the VRS. This was due to the many sources of obstruction, including boundary walls (see figures 7 and 8), and a building on the parcel. The receiver frequently lost lock from the Satellites’ signals. Poor satellite geometry warnings were also frequent from the TCS2 controller, this contributed to poor results obtained for the VRS survey.

Although the two lines for which reasonable comparisons could be made appears acceptable (in distances), the fact that only two boundary lines delivered satisfactory results, suggests that this survey represents those in which it is best to use the VRS to geo-reference the survey (soon to be mandatory) by establishing control points, in the best GNNS friendly locations on the site, and use conventional means of surveying to complete the survey.

As a part of the regulatory requirements for this type of survey, a tie had to be made to the nearest street intersection. This required three (3) traverse stations and about 45 minutes, using the total station. A 300 second VRS occupation of the tie point yielded a difference of 12 mm over the distance of 121.5 m, thereby realising an accuracy of 1/10,123.This is encouraging for the proposed mandatory geo-referencing of cadastral surveys across the island, although our mostly erratic landscape will pose some challenge to even this minimal application, in some areas.

Subdivision

VRS observations that were carried out in the Subdivision of Sydenham Villas, Saint Catherine were challenged by the unavailability of marks as the area is swampy and, according to the residents heavy machinery was used to clear the parcels of vegetation. During the clearing of the land, pegs were either disturbed or knocked out. The intention was to acquire

information for a block of parcels in the subdivision. This was not possible due to the aforementioned circumstances. However, after searching, a few boundary marks were located. Using the VRS receiver to occupy the marks was trouble-free as all locations had a clear view of the sky.

Figure 9 : Occupation of a boundary point at Sydenham Subdivision

The differences in the distances that are of the order of 15 to 33 mm demonstrates that the technology is capable of delivering good results in subdivisions with similar site characteristics to that which obtains in Sydenam. In the other cases, the marks appear to have been disturbed. None of these lines exhibited the minimum (1;1,000) accuracy required under the Land Surveyors Regulation mainly due to the fact that these lines are short. Given that these lines are on average 20 meters, means that a maximum difference of 20 mm would be acceptable. This appears achievable given good site conditions and longer (300 seconds) occupation time. On the other hand, it may be that it is best to confine the use of the VRS to geo-reference the survey, by establishing control and in some instances establish block corners. The lot corners may then be staked on line, using a Total Station.

Summary

The results obtained from the Virtual Reference System (VRS) surveys of the test sites, in some instances, are unfavourable. The differences in Northings and Eastings on the Calibration Network points range from 14 mm to 60 mm. Much better results would be expected, as points are located in an ideal GNSS friendly site. There appears to be a systematic bias between this network and the VRS Network.. The horizontal distance observations differences ranges from 0 mm to 11 mm. Considering that these observations were done in perfect "view" of the sky and conditions were very favourable for GNSS observations, one would have liked to see much better results. It could be that occupation times needed to be longer, depending on the number of satellites available at the time of the survey. If such good conditions are available on cadastral surveying sites, then the system would be very suitable for geo-referencing surveys.

The test observation which was done on the Urban area control points, returned disappointing results. This because the station KG52 was covered with foliage, even though this did not stop the receiver from logging data. The TCS2 controller warned the user with a clear sound 'poor satellite geometry'. The TCS2 controller and the VRS software does not collect data unless Root Mean Squared Error (RMSE) quality indicator falls within the limits entered during the setup stage. The -0.589m difference in Northings may be also as a consequence of other factors including multipath, due to the presence of a building with many glass windows less than 50 meters away from the station. The distance difference of 13.8 centimeters is poor obviously due to unacceptable GNSS site conditions.

The rural survey which is located in the Kitson Town area of Saint Catherine, served up results that are less than acceptable for cadastral surveying standards (Rural – 1/500) in Jamaica. There are significant inconsistencies where the courses are concerned. An acceptable distance measurement was achieved for only one line for which the accuracy a little better than 1:500.The active receiver had problems initializing in this area after initializing the observations were carried out in quick succession of each other. Warnings were, however, received of 'poor satellite geometry and poor observation'. The observations were however still carried out and logged by the instrument. The observations could have been subject to cycle slip which would be caused by the tree canopies in the area.

The subdivision survey which was carried out in the Sydenam area of Saint Catherine, where the acceptable standard of accuracy is expected to be atleast 1/1,000, was also subjected to similar sources of errors to those experienced in the Kitson Town. Although the site was not as dense, there was some difficulty initializing the instrumentation and loss of base station information was frequent. This is due to the fact that voice is given priority over data in the cellular network. If communication channels are occupied by streaming data for the VRS and a cellular phone user dials to make a call, the data streaming will be discontinued if the channel being used to transmit data is the only channel that can effect that call. This situation proves to be very disruptive and can detract from the use of VRS.

In the case of the control points on the UTech campus, there appears to be a systematic bias in the Northings and Eastings of the points, which may be explained by a weakness in the tie of this network to the National Grid. The same can be said for the elevation differences, except of course for point UT09, which appears to be the result of a blunder. The distance differences demonstrate that there is good potential for VRS in this type of environment.

The cadastral observations at the selected urban site, in terms of quality, were poor. In this type of survey our regulations require that the minimum standard of accuracy is 1/2,000. The points were located in proximity to high wall/fences and other structures which blocked satellite signals and caused poor satellite geometry, resulting in poor observations. Some points could not be directly observed as they were covered by structures, others did not allow for a vertical receiver pole because of close structures. Only seven (7) of the fourteen (14) points could be occupied and even these did not yield acceptable results.

Conclusion

The main objective of the research was to determine if the VRS can be used satisfactorily to carry out cadastral surveying in urban, rural and subdivision sites and whether or not our geodetic infrastructure can serve as a good integrity monitor. Satisfactory results in cadastral surveying can be achieved where sites exhibit GNNS friendly conditions. The results from the National Calibration Network, which is to be used for the legal traceability of GNSS measurements in Cadastral Surveys, are encouraging, but also enforce the point that excellent site conditions are mandatory. The results of the test on the University of Technology control network strongly support this argument.

The use of the instrumentation is very practical and simple and with a clear "view" of the sky the system can deliver high accuracies. It allows for more expedient observations in comparison to Total Station surveys. If used in the right conditions i.e. where there is clear unobstructed "view" of the sky, which may be the case in only about 30% of Cadastral Surveys in Jamaica, it can be open to many other practical surveying applications, such as Geodetic, Engineering and Topographical surveying. The Virtual Reference System (VRS) method can be a suitable alternative method of carrying out Cadastral Surveys in Jamaica, provided that there is clear "view" of sky at all boundary points and the pole is able to be held vertically, while on the boundary mark. However, when there are obstructions a combination of conventional instruments and GNSS method can be used to good effect, which involves both the Total Station and the Virtual Reference System (VRS).

The results have demonstrated that the 10cm and 50cm accuracies required in geo-referencing Urban and Rural Surveys respectively, can be achieved, where conditions allow.

Likewise, where national control is located in GNSS friendly locations, they may be used as integrity monitors for the VRS, prior to and after a survey is done, to provide the user with a high level of confidence in the system, that it is providing good results. It is the density of such points that would remain a concern.

Recommendation

The Total Station and VRS approach is therefore recommended whenever such difficulties arise such as in the case of the survey of an urban lot. Monuments which are located in areas with a clear view of the sky can be occupied with an active VRS receiver. Control stations can be set using the VRS and points which cannot be observed using the single active receiver can be surveyed using a total station.

References

Standards & Guidelines for Cadastral Surveys Using Global Navigation Satellite

Systems. (2006, July 26). Retrieved May 9, 2010, from U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT: http://www.blm.gov/pgdata/etc/medialib/blm/ak/aktest/cadastral.Par.14038.File.dat/cad_gps_standards.pdf

A. Pirti, N. A. (2009). Real-Time Kinematic GPS for Cadastral Surveying. *Survey Review*, 339-351.

Al Marzooqi, Y., Fashir, H., & Babiker, T. (n.d.). *Establishment & Testing of Dubai Virtual Reference System (DVRS) National GPS-RTK Network.* Retrieved May 20, 2010, from GIS Development (The Geo Spatial Portal): http://www.gisdevelopment.net/technology/gps/me05_131.htm

Andrews Space & Technology. (2001). *GLONASS Summary*. Retrieved May 10, 2010, from Space & Tech: http://www.spaceandtech.com/spacedata/constellations/glonass_consum.shtml

Collier P.A. and Bowen N.J. (1999) A GDA94 *Transformation Grid for Tasmania*. The Australian Surveyor. Vol. 44, No. 2

Diggelen, v. F. (2009). *A-GPS: Assissted GPS, GNSS, and SBAS.* Boston: Artech House.

El-Rabbany, A. (2002). *Introduction to GPS: The Global Positioning System.* Boston: Artech House.

Encyclopedia of the Nations. (2010). *Jamaica - Location, Size, and Extent*. Retrieved May 12, 2010, from Encyclopedia of the Nations: http://www.nationsencyclopedia.com/Americas/Jamaica-LOCATION-SIZE-AND-EXTENT.html

Estopinal, S. V. (2009). *A Guide to Understanding Land Surveys.* New Jersy: John wiley & Sons Limited.

French, T. G. (1996). *Undestanding The GPS: An Introduction to the Global Positioning System.* Bethesda: GeoResearch Inc.

Geerdts, A. E. (2009). *Eliminating blunders in cadastral work with the use of VRS.*

Girvan, R.A., (1983) *Report on Jamaica MSL Datum with respect to new data received from the U.S. National Ocean Service* Survey Department Internal Report Jamaica

Girvan, R.A., (1983) *Admiralty Datum* Survey Department Internal Report Jamaica

Girvan, R.A., (1984) *Jamaica Horizontal Adjustment (JAD69)* Survey Department Internal Report Jamaica

Gleason, S., & Gebre-Egziabher, D. (2009). *GNSS Applications and Methods.* Boston: Artech House.

Grewal, M. S., & Weill, L. W. (2001). *Global Positioning Systems, Inertial Navigation, and Integration.* New York: Jon Wiley & Sons Limited.

Hakli, P. (2004). Practical Test on accuracy and Usuability of Virtual Reference Station Method in Finland. *Positioning and Measurement Technologies and Practices I - GNSS Networks* (pp. 1-16). Athens, Greece: FIG Working Week.

Hofmann-Wellenhof, B., Lichtenegger, H., & Collins, J. (2001). *Global Positioning Systems: Theory and practice.* New York: Springer Wein.

Jeong, J.-Y. (2010, April 11-16). Use of Network RTK using VRS for a Cadastral Surveying on Islands. *Technology in Land Administration*. Sydney, Australia: FIG Congress.

McCarthy, D. D., & Seidelmann, K. E. (2009). *Time: From Earth rotation to Atomic Physics.* London: Wiley VCH.

Mugnier C. (2003). *Grids and Datums. JAMAICA.* Photogrammetric Engineering & Remote Sensing May 2003

National Research Council. (1995). *The Global Positioning System: A Shared National Assest.* Washinton DC: National Academy Press.

Newsome, G. G. (2001). Towards a Virtual reference System (VRS) for Jamaica.

Retscher, G. (2002). Accuracy Performance of Virtual Reference Station Networks. *Journal of Global Positioning Systems*, 40-47.

Roberts, C. (2005). GPS for Cadastral Surveying - Practical Considerations. *SSC 2005 Spatial Intelligence, Innovation and Praxis: The National Be\iennial Conference of the Spatial Sciences Institute.* Australia: Spatial Sciences Institute.

Robinson, R., (1975). *A critical review of the mapping of Jamaica from 1938 to 1973.* Unpublished R.I.C.S. Final Examination Dissertation

Scott, L., & Beidleman, W. (2006). *GPS Versus Galileo (Balancing for Position in Space).* Alabama: Air University Press.

Seeber, G. (2003). *Satellite Geodesy.* New York: Walter de Gruyter.

Silayo, E. H. (2005, April 16-21). *Searching for an Affordable and Acceptable Cadastral Survey Method*. Retrieved May 9, 2010, from International Federation of Surveyors: http://www.fig.net/pub/cairo/abstracts/ts_39/ts39_03_silayo_abs.pdf

Taylor, G., & Blewitt, G. (2006). *Intelligent Positioning (GIS-GPS Unification).* England: John Wiley & Sons, Limited.

Taylor, N. (2005, June 16). *Cadastral Surveying & Mapping Issues Report.* Retrieved May 22, 2010, from USAID: http://pdf.usaid.gov/pdf_docs/PNADG846.pdf

Tsui, B.-Y. J. (2000). *Fundamentals of Global Positioning System Recievers: A Software Approach.* New York: John Wiley & Sons Inc.

U.S. Department of Homeland Security. (1996, September). *NAVSTAR GPS User Equipment Introduction.* Retrieved May 10, 2009, from Navigation Center: The Navigation Center of Excellence: http://www.navcen.uscg.gov/pubs/gps/gpsuser/gpsuser.pdf

US Army Corps of Engineers. (2003, July 1). NAVSTAR Global Positioning System Surveying. *Engineer & Design*. Washington DC, United States of America: Department of the Army.

It pretty much flies itself!

The Massachusetts Institute of Technology's Robust Robotics Group has developed a plane that can navigate itself without GPS. For decades, researchers have been working on creating helicopters that can pilot themselves without human guidance. But MIT's team has now come up a fixed-wing plane that can travel at high speeds while dodging obstacles and manoeuvring through tight spaces. Using only on-board sensors, a laser, and a basic Intel Atom processor, the aircraft is able to power itself. *http://www.dailymail.co.uk*

BeiDou navigation system to have test network

China will build a testing and certification network for its Beidou satellite navigation system over the next three years to sharpen the system's global competitiveness, according to a statement from the Certification and Accreditation Administration. An authoritative testing and certification system with uniform standards and legal support will secure the Beidou system's safe operation and accelerate its industrialization, said the statement. *http://www.indianexpress.com*

TSB priority to use agricultural GPS equipment

The head of Britain's Technology Strategy Board (TSB) has said that they are working hard to ensure that GPS technology is further integrated into the national farming industry. Iain Gray said that GPS positioning and machine control technology has been in use in British agriculture for more than 15 years now, but there are still many farming operations in the UK that are not taking full advantage of it. Only 10 per cent of the operations in the National Farm Research Unit database, however, "could be called innovative based on criteria including business approach",according to Gray. The total farming and food sector in the UK is worth around £85 billion, providing a total of around 3.5 million jobs. *http://www.surveyequipment.com*

North Korean jamming of GPS shows system's weakness

U.S. and South Korean military commanders will be on the lookout for North Korean efforts to jam GPS signals as they take part in exercises on the divided peninsula soon. North Korea repeatedly has jammed GPS signals in South Korea, which has "very serious implications" because U.S. and South Korean military system rely on the navigation system, said Bruce Bennett, a North Korea scholar for the California think tank Rand Corp. North Koreans have used Russian-made, truck-mounted jamming gear near the border to disrupt low-power GPS signals in large swaths of South Korea. *http://www.washingtontimes.com*

GPS technology finding its way into court

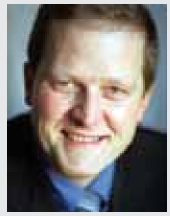
The rapid spread of cellphones with GPS technology has allowed police to track suspects with unprecedented precision even as they commit crimes.

The U.S. Court of Appeals for the 6th Circuit stirred the debate recently when it supported police use of a drug runner's cellphone signals to locate him — and more than 1,000 pounds of marijuana at a Texas rest stop. The court decided that the suspect "did not have a reasonable expectation of privacy" over location data from his cellphone and that police were free to collect it over several days, even without a search warrant.

The decision riled civil libertarians, who warned that it opened the door to an extensive new form of government surveillance destined to be abused as sophisticated tracking technology becomes more widely available.

Many legal experts expect the issue eventually to find its way to the Supreme Court, which touched on it in an earlier ruling that police violated the rights of an alleged D.C. drug dealer by placing a tracking device on the underside of his car. Cellphones always have been trackable to some degree, as users moved among towers that carried the signals necessary to make the devices work, creating an electronic record in the process. But GPS technology is far more sophisticated, narrowing locations typically to within a few feet. *The Washington Post*

Tragic Loss for International Hydrographic Community



On 31 August, the survey ship Level A collided with a Belgian-propelled barge on the Rhine at Basel, Switzerland, and capsized. The four crew members fell overboard. Although Professor Dr Volker Böder, director of the project and professor of geodesy and hydrography at the HafenCity University Hamburg (HCU), was rescued, he sadly died in hospital the following day as a result of his injuries.

Professor Dr Volker Böder made an enormous contribution to encouraging young professionals to join the hydrographic industry. He was one of the driving forces behind the international hydrographic exchange programmes that were established between higher educational institutes throughout Europe. He realised that the hydrographers of the future would be operating in a global industry and that it was therefore important for students to gain international experience at an early stage – an initiative which deserves to be remembered. *http://www.hydro-international.com*

Israeli European GNSS Info Centre Launched

MATIMOP, the Israeli Industry Centre for R&D launched the Israeli European GNSS (ISEG) Information Centre, a new initiative aimed at increasing the visibility of EU Satellite Navigation Programmes and activities in Israel. The centre is operated by MATIMOP with the support of the European Union. *http://www.matimop.org.il/*

Police urge hill walkers to use maps and not apps

Northern Constabulary are urging hill walkers not to rely solely on 'smartphone' apps for navigation. On two occasions in recently, both Police and Cairngorm Mountain Rescue Team have been involved in the rescue of lost walkers who were relying entirely on apps which proved to be insufficient on their own.

Aviemore, Scotland, Inspector Kevin MacLeod stated: "When you consider the dangers of getting lost in the mountains or of taking a false turn, it would be difficult to over-state the importance of being able to navigate accurately. 'Smartphone' apps are a great innovation but, on their own, they are not reliable enough for navigation in the mountains.

"In addition to being suitably experienced and equipped, walkers should have, and know how to use, a map and compass or other suitable navigational device." *http://www.stornowaygazette.co.uk*

skobbler Leverages Skyhook to Enable Location in ForeverMap 2

Skyhook has announced that skobbler has integrated Skyhook's Location Engine in ForeverMap 2(tm) to provide location services for the first time on NOOK(r). ForeverMap 2, available for FREE on NOOK Apps(tm), is the first-ever map app on NOOK, enabling users to experience and explore their surroundings like never before. *http://www.finwin.com*

JiWire Rolls Out 'Location Graph'

Location-based ad company JiWire has unveiled a new ad service designed to help marketers target specific audiences based on the billions of pieces of location data it has collected. The company's Location Graph harnesses that data to create anonymous user profiles based on the types of places people visit, from beauty parlors to drug stores to airports.

Instead of defining audiences by social connections, like Facebook's famed social graph, JiWire's new targeting capability relies on historical (and present) location data to improve campaign performance. *http://www.mediapost.com*

Real-time traffic alerts by Tata Docomo

Tata Docomo has launched a traffic SMS alert service for its prepaid and postpaid subscribers in Bengaluru, India. This service will allow subscribers to choose a start and an end destination and a specific time to receive real time traffic information along the route. This is Tata Docomo's second LBS initiative: it had launched an SMS and WAP driven location based service called Route Finder in its 3G circles and Mumbai in June last year. *http://www.medianama.com/*

Drive your cars using Smartphone App

Australian scientists say they are developing technology which will enable your smartphone to drive your car. Researchers say they will be road testing a vehicle which uses a phone's satellite navigation technology and camera to drive along the street within a year. Dr Jun Jo from Griffith University and his team have built a prototype car which they are using to test the software. The vehicle has an onboard computer, radar system and sensors which communicate with the phone.

The race is on to develop driverless, or autonomous, vehicles with many motor manufacturers investing in research. In the US, Google has just been issued with the first licence for an autonomous car in Nevada. A Toyota Prius has been fitted with the company's driverless technology. *http://news.sky.com/*

Indoor Navigation on Mobile Devices for guidance

STMicroelectronics has worked with the Museum of Contemporary Art in Taipei to enrich the experience of visitors to Taiwan-based Chinese film-director King Hu's works exhibition through the use of indoor navigation. This technology transforms mobile phones and other smart consumer devices into the most convenient source of real-time information about the exhibition. Accurate indoor positioning is the key enabler for LBS, widely considered the next "killer application" in the mobile world. *http://www.reuters.com/*

Scout Drive Button: GPS Navigation for Websites

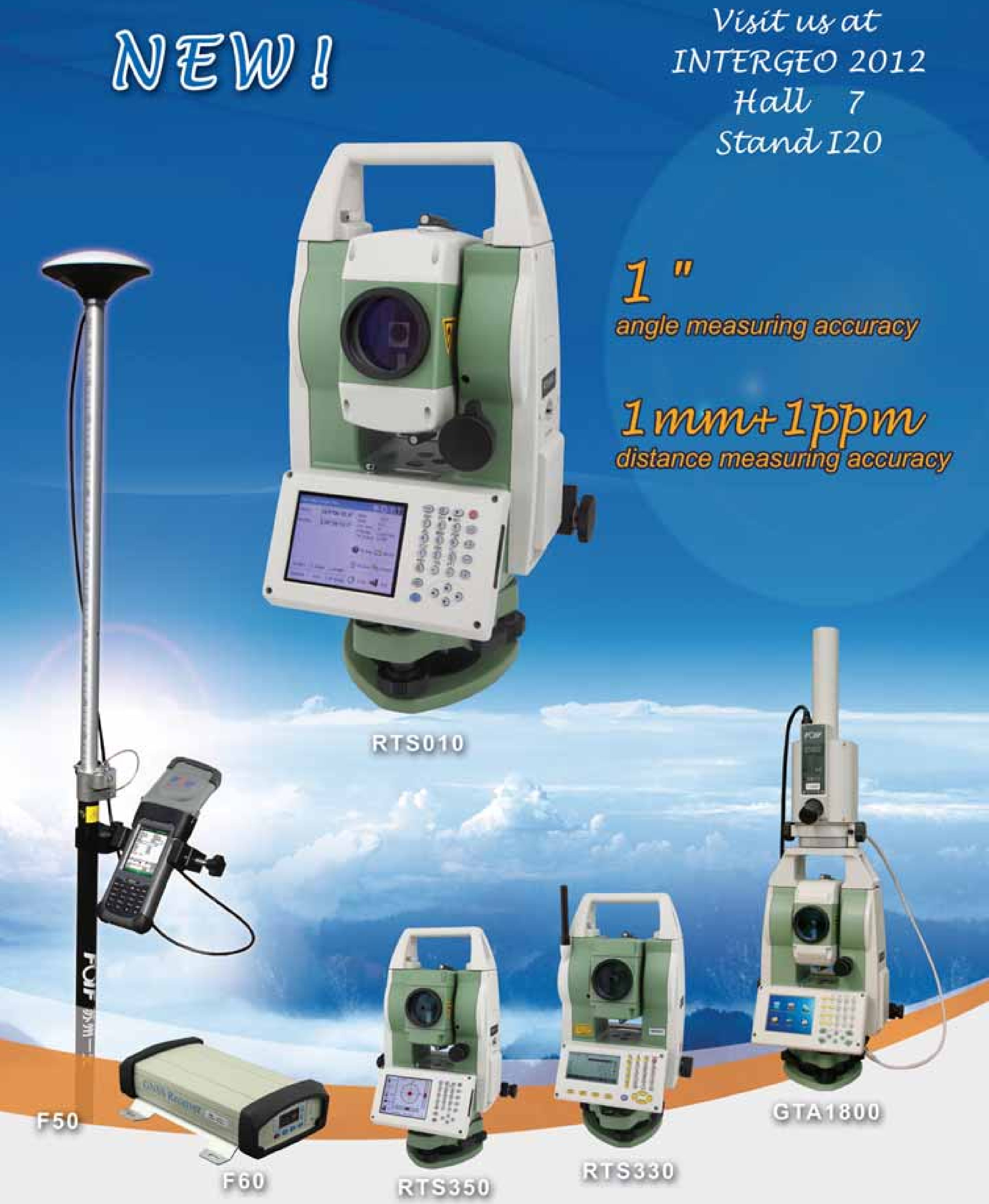
Telenav has launched Scout Drive Button, a widget for anyone to add onto their website to provide visitors the ability to instantly launch voice-guided, turn by turn, GPS navigation to their store, restaurant, salon, dentist office, etc. Mobile users can click the button from their phone and navigation will start from their mobile browser, without the need for a separate GPS navigation or mapping app.

Nokia, Samsung, Sony join forces to improve indoor navigation

Nokia, Samsung Electronics, Sony and Qualcomm have formed the In-Location Alliance, which will work to improve the accuracy of indoor positioning, which is the next frontier of mobile services. Finding out where you are in a mall or a sports arena using a smartphone is difficult today because GPS coverage usually isn't available. Besides improving navigation accuracy in those kinds locations, the In-Location Alliance will also prioritize low power consumption and making the technology both easy to implement and use. The primary underlying technologies will be Bluetooth 4.0 and Wi-Fi. *http://www.computerworld.com*

Trimble adds RFID capabilities to AllTrak

Trimble® AllTrak™ Asset and Tool Management System includes an RFID scanner for its Trimble Nomad® outdoor rugged handheld computer running the Microsoft® Windows Mobile operating system. It allows building construction contractors to more easily track and manage their jobsite assets and tools. In addition, the system increases return on investment by improving asset utilization and monitoring equipment to avoid losses. *http://www.trimble.com*


NEW!
Visit us at
INTERGEO 2012
Hall 7
Stand I20
1"
angle measuring accuracy
1mm+1ppm
distance measuring accuracy
RTS010
F50
F60
RTS350
RTS330
GTA1800

Be more competitive in marketing Indian Remote Sensing data: PAC to NRSC

Dismayed over “negligible” returns from sale of satellite imagery, a Parliamentary panel has asked the National Remote Sensing Centre (NRSC), India to be more competitive in data marketing. The Public Accounts Committee, in a draft report on activities of the NRSC, appeared to brush aside Department of Space (DoS) contention that remote sensing was treated as a “public good service” rather than commercial activity.

It said that appropriate customised packaging of remote sensing data by way of adequate value addition and making them fit for synergistic and simultaneous applications will definitely enhance the marketability of such data and bring about increase in net returns. The Committee said it was dismayed to note that while the total capital investment on seven remote sensing satellites between 2003-08 was Rs 1468.59 crore, operational returns ranged from Rs 96.87 crore to Rs 134.27 crore.

On lower pricing of Indian Remote Sensing (IRS) data, the DoS said that it was not comparable with foreign satellite data which is available in finer resolution. The DoS noted that imagery obtained from Geoeye1 or Worldview2 satellites was of 0.5 meter resolution with multispectral and stereo capability. “There is no equivalent data from IRS. Hence the prices are not comparable,” the DoS said. *http://articles.economictimes.indiatimes.com*

DigitalGlobe reports 23 percent revenue increase

DigitalGlobe has reported a 23 percent increase in revenue during the recent quarter, compared with last year. The satellite imagery company said it had $101.8 million in revenue in the second quarter, compared with $82.5 million during the second quarter of 2011. It reported net income during the recent quarter of $9.6 million, or 21 cents per diluted share, compared with a net loss of $900,000, or 2 cents per diluted share, for the same period last year. *http://www.timescall.com*

Arctic ice thinning faster than thought

"Preliminary analysis of our data indicates that the rate of loss of sea ice volume in summer in the arctic may be far larger than we had previously suspected," said Seymour Laxon of the Center for Polar Observation and Modeling at University College London where the information gathered by CryoSat-2, designed specifically to measure sea ice and launched in April 2010, is being analyzed. "Very soon we may experience the iconic moment when, one day in the summer, we look at satellite images and see no sea ice coverage in the arctic, just open water."

Laxon notes, however, these are preliminary figures, "so we should take care before rushing to conclusions." *http://www.upi.com/Science_News*

PolyU study raises alert for further increase in HK city's temperature

The temperature in the inner urban areas of Hong Kong is predicted to rise by two to three Celsius degree in 30 years' time, according to the latest scientific study by researchers at the Department of Land Surveying and Geo-Informatics (LSGI) of The Hong Kong Polytechnic University (PolyU).

The study was done by PolyU Professor Janet Nichol and her research student Mr To Pui-hang, together with Chinese University's Professor Edward Ng Yan-yung, using remote sensing technology and satellite images. They have mapped the distribution of temperatures for both daytime and nighttime over Hong Kong at decadal intervals up to 2039, taking into consideration the temperature change due to greenhouse-induced warming as well as the impact of urbanization. *http://www.rdmag.com*

European data center for GMES Sentinel satellites at DLR

The ground segment for GMES (Global Monitoring for Environment and Security) is starting to take shape: The German Remote Sensing Data Center (DFD) of the German Aerospace Center (DLR) in Oberpfaffenhofen will be the European data center for GMES satellites Sentinel-1 and Sentinel-3. Starting in 2013, data from Sentinel-1, and later also data from the land and ocean sensor on the Sentinal-3 satellites (the Ocean and Land Color Imager, OLCI) will be processed to yield information products, distributed to users, and archived long-term. ESA is providing 13.6 million euro over seven years to establish and operate the data center. *www.dlr.de/eoc/en/*

New remote-sensing satellite on the job

China's first high-resolution, remote-sensing satellite for civilian use, Ziyuan 3 put into service recently is marking a breakthrough in the country's drive to map the Earth from outer space.

Unlike the Ziyuan 1 and 2 satellites, which produce only 2D images, the new satellite can produce 3D imagery thanks to three cameras attached to it at different angles. The images' resolution is 2.1 meters, better than the previous resolution of 3 meters. The orbiter also has a multispectral camera that helps look for mineral resources, which can produce imagery with a resolution of 6 meters. The satellite can transmit data at a speed four to five times of previous satellites. And for the first time, a low-Earth-orbit remote-sensing satellite's lifespan is now five years, up from three years, according to a news release provided by the State Administration of Science, Technology and Industry for National Defense. *http://usa.chinadaily.com.cn*

Myanmar to launch small EO satellite

Myanmar will launch a small earth observation satellite, according to the report published in CRI Online. The satellite will be launched by the Japanese company Marubeni Aerospace and will be used by the Department of Meteorology and Hydrology Department of Transport Burma.

Galileo update

Next Galileo satellite reaches French Guiana launch site

The next Galileo navigation satellite has touched down at Europe's Spaceport in French Guiana, to begin preparations for its launch in October. These third and fourth Galileo 'In-Orbit Validation' (IOV) satellites are due to be launched aboard a Soyuz ST-B vehicle in October. These new satellites will join the first two Galileo satellites - launched last year - in medium-Earth orbit at 23 222 km.

This will mark a significant step in Europe's programme because it will complete the deployment of infrastructure required for the IOV phase and will allow for the first time a computation of on-ground position based solely on Galileo satellites. *http://www.spacedaily.com*

Pre-launch verifications underway with initial Galileo satellite

Europe's Galileo Flight Model #3 (FM3) satellite is undergoing checkout at the Spaceport in preparation for launch along with its "sister" FM4 co-passenger on Arianespace's next Soyuz mission from French Guiana, which is targeted for the second half of 2012. Initial activity with FM3 in the Spaceport's S1B clean room facility includes propulsion sub-system testing and a fit check with hardware for the dual-satellite payload arrangement on Soyuz. It was delivered last week, arriving aboard a chartered cargo jetliner from Europe. *http://rpdefense.over-blog.com*

Galileo Satellite Navigation Agency moved to Prague

The European GNSS1 Agency (GSA) will inaugurate its new premises soon in Prague, in the presence of Commission Vice-President Antonio Tajani, in charge of Industry and Enterprise and Minister of Transport Pavel Dobeš. Previously headquartered provisionally in Brussels, the GSA has moved its seat to Prague over this summer, as had been agreed by the EU Heads of State and Government on 10 December 2010. *http://europa.eu*

Vecmap tracks the Asian bush mosquito

Under the watchful eye of ESA's Vecmap initiative, the Asian bush mosquito is about to get bitten in Belgium. First observed in Belgium in 2002, the Asian bush mosquito can spread viruses such as Chikungunya, Dengue, and West Nile. Vecmap tests the accurate mapping of mosquitoes in Europe and in particular, mosquitoes carrying diseases. It provides a one-shop-stop that simplifies the entire mosquito mapping process by defining key habitats based on field data and delivers risk maps for a wide range of users. *http://www.esa.int/*

Google gets the Baidu blues again after mapping losses

Google looks like being beaten again in China, as Baidu leaps ahead in the mobile mapping space. The text ads giant was still second in the Quarterly Survey of China's Mobile Map Client Market, but only just!

Chinese player Autonavi was the market leader by a long way, with 25.7 per cent, and Google Maps came in second with 17.5 per cent, but had Baidu breathing down its neck in third with a 17.3 per cent share. *http://www.theregister.co.uk*

Dubai completes Dubai Map and 360 degree Panorama projects

The Geographic Information Systems Department at Dubai Municipality announced the successful completion of Dubai Map and 360 degree Panorama projects. The Project consist of taking pictures using a device made of synchronized cameras equipped with special lens mounted on a car roof or on a tripod as in the case of Historical Building Panorama project for the Architectural and Heritage Department. These images are stitched together and processed later using some software to form a complete 360 by 180 view for different locations of the emirate of Dubai. Once stitched, the resulting Georeferenced images give the possibility to visit different locations virtually without the need for videotaping or site visiting. *http://www.khaleejtimes.com*

CBSE, India introduces course in geospatial technology

The Central Board of Secondary Education (CBSE) has now introduced a vocational course on "Geospatial Technology" for its higher secondary students, scheduled to come into effect from the 2013-2014 session.

The course offers an opportunity for the students to understand the basics of the technology dealing with mapping and applications. Students will now get an insight into the diverse geospatial database concepts, creating and implementing the same, GIS theory and spatial analysis, supplemented by extensive practical exercises. The new subject will be offered as a single vocational elective in class XI and XII. Students can opt for it as an elective with any other combination of subjects at the senior secondary level or as an additional sixth subject as per the scheme of studies of the Board. *http://www.deccanherald.com*

Australia creates world's first continental-scale mineral maps

The world-first maps were generated from a ten-year archive of raw Advanced Spaceborne Thermal Emission and Reflection (ASTER) data collected by NASA and the Japanese Government's Japan Space Systems.

CSIRO scientists have developed software that transformed the data into a continent-wide suite of mineral maps that show information about rock and soil mineral components and provide a Google-like zoom to view images from thousands of kilometres wide to just a few kilometres. They are already changing the way that geoscientists look for mineral deposits by providing more accurate and detailed information than ever before. *http://www.csiro.au/en*

Malaysia to Improve Crime Mapping Portal

The technical development team at the Federal Department of Town and Country Planning (FDTCP) is working together with the Royal Malaysian Police to extend the mapping capabilities of its Safe City Monitoring System (SCMS) to other divisions of the police force. The system is a web-based GIS crime mapping tool which aims to not only help authorities identify high crime areas, but to also allow them to study crime patterns and potential variables and determinants on causes of crimes. *http://www.futuregov.asia/*

China to support geoinformation industry

China is expected to introduce policies soon that will give preferential treatment to the geoinformation industry, which is predicted to produce 1 trillion yuan ($157 billion) worth of goods and services by 2020. The policies, which are likely to be issued by the State Council will call for the use of tax cuts and other measures to support the industry, according to Cao Hongjie, vice-president of Beijing UniStrong Science & Technology Co Ltd, a Chinese maker of navigation products. *http://www.chinadaily.com.cn/*

'Chile to save USD 15 mn using GIS model'

A new GIS-based tool, Mapping Urban Parcel (CBPU), will be introduced soon in Chile. CBPU is expected to be operational throughout Chile by 2016. This tool will provide information like, location of police stations, hospitals, risk areas, houses affected to disaster etc. So far, this information came from outsourced companies. But now, Chile hopes to save around USD 15 million through this state owned tool. *http://www.df.cl*

Ghana policy to regulate surveying and mapping

The Ministry of Lands and Natural Resources under the Land Administration Programme (LAP) is developing a policy to regulate survey and mapping in the country. According to the sector minister, Mr. Mike Allen Hammah, the policy was to help promote effective land administration and to a conductive environment for survey practice in the country. *http://www.ghana.gov.gh*

J-Shield from Javad

Javad has improved their GNSS protection filters to not only protect the L1 band against all interferences (including LightSquared 10L, 10H and 10R handset) but to protect against all other interferences which may come in any other GNSS band. This will be known as "J-Shield". This will help to make the bands near any GNSS band to be freed for other usages like broadband wireless which U.S. desperately needs to catch up with other nations (currently US is number 16 in the world) and to help to create competition to potentially reduce the wireband costs in US to 1/3 of what is today. The details will be presented at ION conference in Nashville. *http://javad.com/jgnss/javad/news/pr20120816.html*

Topcon HiPer SR

Topcon Positioning Systems (TPS) announces the new HiPer SR – a highly advanced GNSS RTK receiver with the most compact and lightweight design of any fully integrated precision receiver. With the HiPer SR, Topcon is expanding the delivery of high-accuracy RTK technology to a variety of users – surveyors, non-traditional users such as landscape architects, law enforcement or any others requiring high-accuracy 3D positioning. *http://www.topconpositioning.com/*

F4devices hardware solutions now available from esri

F4Devices is announcing a new partnership with Esri. The Flint rugged handheld is now available in three different offerings for US customers - Esri's ArcPad, ArcGIS for Windows Mobile for ArcGIS for Desktop, and ArcGIS for Windows Mobile for ArcGIS for Server.

Trimble AP20-C GNSS Inertial OEM Module

Trimble has introduced the AP20-C, the latest addition to its AP Series of embedded GNSS-Inertial OEM boards plus Inertial Measurement Unit (IMU). Using a compact, custom-built IMU based on commercial Micro Electromechanical Machined (MEMS) inertial sensors, the AP20-C enables system integrators to achieve high-rate position and orientation measurements with exceptional accuracy. Featuring proven Applanix IN-Fusion™ GNSS-Inertial integration technology, the AP20-C is an embedded GNSS-Inertial OEM board set plus IMU designed for continuous mobile positioning in poor signal environments and high-accuracy direct georeferencing of imaging sensors. *www.trimble.com/GNSS-Inertial*

RTK technology solution for secure GPS receivers by Rockwell Collins

Rockwell Collins has launched the first operational Real Time Kinematic (RTK) Selective Availability Anti-Spoofing Module (SAASM) technology solution for secure GPS receivers.

Unmanned aircraft systems (UAS) can now achieve centimeter-level relative navigation accuracy for autonomous capture, landing, or other operations, while benefiting from the high-security features of the SAASM GPS receiver. The RTK SAASM solution also enables cost-effective solutions for many other applications including targeting and north-finding applications. *www.rockwellcollins.com*

MicroSurvey® releases MicroSurvey CAD 2013

MicroSurvey has released MicroSurvey CAD 2013. This latest version – built for surveyors, contractors and engineers – is based on the completely new and redesigned IntelliCAD 7.2 engine.

It has many new features and improvements, such as MrSID (.sid) file support, new entity snap modes, a dockable properties pane, faster display graphics, DGN import and non-rectangular viewports.

Bentley and CABRTech sign MOU

CABR Technology (CABRTech) Co., Ltd and Bentley Systems have signed a memorandum of understanding (MOU). The MOU establishes a long-term partnership between the two companies to advance building information modeling (BIM) software interoperability in China. CABRTech will facilitate data exchange between its PKPM structural design products and Bentley software. This initiative will provide increased information mobility among the users of PKPM software and all Bentley Integrated Structural Modeling (ISM)-enabled products. *www.cabrtech.com, www.bentley.com*

New Hemisphere GPS Partners in Brazil and China

Hemisphere GPS has announced distribution partnerships in Brazil and China for their flagship S320™ GNSS survey receiver. It has expanded the partnership with Brazilian-based SightGPS, which recently launched Hemisphere GPS' S320 in Brazil under the product name TechGEO GTRi and pre-purchased a significant initial quantity from Hemisphere GPS.

Hemisphere GPS is also announced a new partnership and the receipt of a significant volume commitment with Suzhou Phenix of Suzhou, China. *www.hemispheregps.com.*

NVS Technologies AG Selected by Advanced Navigation

Advanced Navigation has recently launched its Spatial product series, featuring NVS Technologies AG's NV08C-MCM high performance multiple GNSS-constellation receiver. The Spatial is a ruggedized miniature GNSS/INS & AHRS system that provides accurate position, velocity, acceleration and orientation under the most demanding conditions. It combines temperature calibrated accelerometers, gyroscopes, magnetometers and a pressure sensor with an advanced GNSS receiver. These are coupled in a sophisticated fusion algorithm to deliver accurate and reliable navigation and orientation. *www.advancednavigation.com, www.nvs-gnss.com*

Leica GNSS Spider v4.3 integrates Leica GM10 GNSS Monitoring Receiver

Leica Geosystems released new Leica GNSS Spider software version 4.3. The integration of the new Leica GM10 and many further enhancements respond to market demands and technology trends. With Leica Geosystems' Customer Care Program, GNSS network providers profit from an always state-of-the-art product at no additional investment.

GPS-GLONASS-GAGAN MODULE Developed by Accord for DRDO

M/s.Accord Software & Systems Pvt. Ltd, has developed a highly miniaturized Module with all the available Satellite Constellations of GPS, GLONASS and GAGAN called G3oM for Defence Research and Development Organisation and it was handed over to Dr V.K. Saraswat, Director General, DRDO recently.

G3oM a tiny module with a form factor of 40mmX40mmx6.8mm weighing just 17 grams can be used in variety of applications like Aircrafts, Helicopters, Mobile Vehicles, Boats, Ships and Survey applications. The Component has got tremendous Civilian use and can be produced in large numbers at a low cost. G3oM is a state-of-the-art technology receiver which integrates both GPS and Indian SBAS GAGAN and GLONASS systems. The Algorithms designed to run on the modules are capable of providing superior time to fix, signal sensitivity, accuracy along with integrity monitoring and anti-spoofing. The navigation output comprises of GPS, GLONASS and GPS+GLONASS position, speed and time data. G3oM supports a scalable architecture designed to cater to future navigation systems like IRNSS, GALILEO etc.

Dr V.K. Saraswat, Scientific Advisor to the Defence Minister of India, said that this is an example where DRDO in collaboration with Private Industry has carried out Research in advanced areas and developed a product which finds its application extensively in Civilian Sectors. Sri J. M. Sundaresan, MD, M/s. Accord said that the company's in-house R&D initiatives over the past two decades have resulted in leadership in the area of GNSS technology. This has enabled Accord to participate and contribute in the indigenous development of state-of-the-art G3oM product in partnership with DRDO.


NovAtel Inc. 1120 – 68th Avenue N.E. Calgary AB Canada T2E 8S5
Tel: 1-800-NovAtel (1-800-668-2835) Internet: www.novatel.com

Chronos welcomes Ofcom licensing regime

Chronos Technology has welcomed the recent decision by the UK regulator Ofcom to implement a licensing regime for the use of GNSS repeaters in the UK. GNSS repeaters provide coverage for the use and testing of GNSS technology inside buildings where the GNSS signals do not normally reach. Until the recent decision by Ofcom, the use of this repeater technology in the UK was not permitted except in specialized (normally military) situations. The Ofcom consultation prior to this decision highlighted concerns about potential interference to applications by the use of GNSS repeaters, however the conclusion was that a properly installed repeater system, conforming to the ETSI harmonized Standard for GNSS repeaters should have no impact beyond 10 metres. *www.chronos.co.uk*

Palm-sized GPS/GLONASS RTK Receiver by Geneq

Geneq Inc. has announced the SXBlue III GNSS, a palm-sized GNSS RTK receiver that uses both GPS and GLONASS for real-time, centimeter accuracy. Via Bluetooth, it brings centimeter accuracy to any smartphone, handheld, tablet, or notebook computer that is Bluetooth-compliant.

The SXBlue III GNSS uses new, patented technology that allows it to generate corrections for both GPS and GLONASS satellite data even if the user's reference station (or RTK Network) only supports GPS. This features opens up productivity benefits of GLONASS to all high-precision users around the world, and not just ones who have access to GLONASS-enabled reference stations. *http://www.sxbluegps.com/sxblueIII-gnss.html*

MARK YOUR CALENDAR

October 2012

IAIN 2012 Conference
1 – 3 October
Cairo, Egypt
www.ainegypt.org

GISSA Ukubuzana 2012
2 - 4 October
Gauteng, South Africa
www.gissa.org.za

UPINLBS 2012 Conference and Exhibition
3 – 4 October
Helsinki, Finland
http://217.152.180.26/upinlbs/

INTERGEO 2012
9-11 October
Hanover, Germany
www.intergeo.de/en

XXXII INCA International Congress
11 – 13 October
Dehradun, India
sajeevnair_inca32@yahoo.com

GIS-IDEAS 2012
16-20 October
Ho Chi Minh City, Vietnam
http://gisws1.media.osaka-cu.ac.jp/gisideas12/

Esri Malaysia User Conference 2012
23 & 24 0CTOBER 2012
PUTRAJAYA, Malaysia
http://www.esrimalaysia.com.my

19th ITS World Congress
22 – 26 October
Vienna, Austria
http://2012.itsworldcongress.com/content/congress

19th United Nations Regional Cartographic Conference for Asia and the Pacific
29 October - 1 November
Bangkok, Thailand
http://unstats.un.org/unsd/geoinfo/RCC/unrccap19.html

The International symposium on GPS/GNSS 2012
31 October - 2 November
Xi'an, China
www.gpsgnss2012.com

November 2012

Trimble Dimensions User Conference
November 5-7
Las Vegas, USA
http://www.trimbledimensions.com/

2012 International Conference on Indoor Positioning and Indoor Navigation (IPIN)
13-15 November
Sydney, Australia
www.surveying.unsw.edu.au/ipin2012

spatial@gov® Conference and Exhibition 2012
20 – 22 November
Canberra, Australia
www.cebit.com.au/spatial

8th Fig Regional Conference
26 - 29 November
Montevideo, Uruguay
www.fig.net/uruguay

The 33rd Asian Conference on Remote Sensing
26 - 30, November
Pattaya, Thailand
http://acrs2012.gistda.or.th

December 2012

European LiDAR Mapping Forum
4 - 5 December
Salzburg, Austria
www.lidarmap.org

NAVITEC 2012
5 - 7 December
Noordwijk, Netherlands
www.congrexprojects.com/12c13/introduction

4th Asia Oceania Regional Workshop on GNSS
9-10 December
Kuala Lumpur, Malaysia
www.multignss.asia

January 2013

ION International Technical Meeting
27 – 29 January
San Diego, California, United States
http://ion.org/meetings/

February 2013

Second High Level Forum on Global Geospatial Information Management
4-6 February
Doha, Qatar
http://ggim.un.org/

The International LiDAR Mapping Forum
11-13 February
Colorado, USA
www.lidarmap.org

The Munich Satellite Navigation Summit 2013
26 – 28 February
Munich Germany
www.munich-satellite-navigation-summit.org

April 2013

Pacific PNT
22-25 April 2013
Honolulu, Hawaii
www.ion.org

35th International Symposium on Remote Sensing of Environment
22 - 26 April
Beijing, China
http://www.isrse35.org

June 2013

TransNav 2013
19 - 21 June
Gdynia, Poland
http://transnav2013.am.gdynia.pl

SIMPLY. AMAZING.

COMPACT, DUAL FREQUENCY BOARD

When power consumption, size and dependable performance such as raw data quality and/or real-time positioning are critical, the Ashtech MB 100 GNSS board simply delivers! It features internal heading and Z-Blade™ Technology for amazing long-range dual frequency RTK performance or dependable L1 GPS+GLONASS+SBAS positioning.

RUGGED AND COMPACT GNSS SYSTEM

The HDS800 is a rugged dual board GNSS system that delivers state-of-the-art RTK accuracy, including heading and relative positioning. Designed for seamless onboard system integration, it is available in a variety of configurations. Embedded Z-Blade™ technology ensures powerful RTK performance and a patented way to use multiple GNSS constellations for high-accuracy positioning and surveying solutions.

Z-Blade

Ashtech's Z-Blade™ Technology is a unique patented method using multiple GNSS constellations for high-accuracy positioning. Z-Blade technology secures the best possible measurements from the GPS, GLONASS and SBAS constellations and mixes multiple observables with no compromise between quality and availability. This leads to an incredibly robust and dependable measurement processing resulting in optimized productivity.

- New Ashtech GNSS centric signal processing:
  Fully independent GNSS satellites tracking and processing
- Fully independent code and phase measurements
- Ability to work in GLONASS-Only mode
- Outstanding reliability in urban canyons and under tree canopy
- Multi-frequency and multiconstellation ready
- Advanced multi-path mitigation

SKYNAV® GG12W™ GPS+SBAS BOARD

The SkyNav GG12W is ideally suited for integration within Technical Standard Order (TSO) Flight Management Systems (FMS), ground-based reference stations for GPS aircraft landing systems (SCAT I and LAAS) and other avionics. In addition to traditional GPS receiver design and ISO 9001 engineering practices, the SkyNav GG12W adheres to all FAA/RTCA design criteria.

MULTI-CONSTELLATION, MULTI-FREQUENCY BOARD

With the new MB 800 multi-constellation board, Ashtech brings to the OEM market a unique blend of technologies which increases RTK availability and data integrity. Embedded Z-Blade™ technology ensures powerful performance and a patented way to use multiple GNSS constellations for high accuracy positioning, and surveying solutions.

ashtech™
A TRIMBLE COMPANY

www.ashtech-oem.com

oemsales@ashtech.com

See us at
ION GNSS 2012
Trimble Booth C

ION GNSS 2012

PENTAX | W-800 SIMPLE OPERATION MODULAR SOFTWARE

LONG RANGE EDM

Measures distances in reflectorless mode over 550 m and 9000 m (*) to a single prism while maintaining the same high level of accuracy.

Benefits: Its extended measuring range prevents you from making additional instrument setups.

(*) in good conditions (40km visibility)

W-800 SERIES

R-400N SERIES

R-400VN SERIES

TI Asahi Co., Ltd.
International Sales Department
Tel.: +81-48-793-0118
Fax. +81-48-793-0128
e-mail: international@tiasahi.com
www.pentaxsurveying.com/en/

Pentax Distributor for INDIA
LAWRENCE & MAYO PVT. LTD.
274, Dr. Dadabhai Naoroji Rd.
Mumbai 400 001, INDIA
tel: +91 22 22 07 7440
fax: +91 22 22 07 0048
email: instmum@lawrenceandmayo.co.in
www.lawrenceandmayo.co.in

JSIMA
Japan Surveying Instruments Manufacturers' Association

Member symbol of the Japan Surveying Instruments Manufacturers' Association representing the high quality surveying products.


MAKE EXACT POSITIONING A SIXTH SENSE
SPAN®. Your positioning superhero.
SPAN is the world's most reliable OEM GNSS/INS technology, with the ability to provide continuous position, velocity and attitude. So an unprecedented mission—like landing an unmanned helicopter on a moving marine vessel—no longer stands in the way of success. Imagine how this kind of sensory superpower will help you rule in your world. As always, we'll keep your identity secret. To find out more, visit novatel.com/span or call you know who.
NovAtel
Integrate success into your .